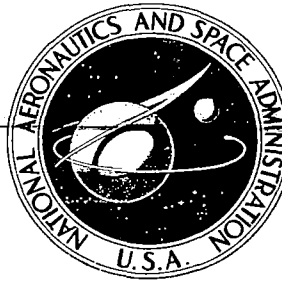


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A FURTHER STUDY OF  
JIMSPHERE WIND PROFILES AS  
RELATED TO SPACE VEHICLE  
DESIGN AND OPERATIONS

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*for George C. Marshall Space Flight Center*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION • WASHINGTON, D. C. • AUGUST 1970



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| 16. Abstract      Statistical characteristics of steady state winds, gusts and wind shears observed over Cape Kennedy, Florida, and Point Mugu, California, with Jimsphere balloon sensors are described. Gusts in Jimsphere wind profiles as viewed in the time coordinates of a Saturn vehicle were isolated from the original profiles with a 33 weight digital high pass filter with negligible transmission of wind fluctuations at frequencies less than 0.15 cps. The distribution of gust variance computed for three 10-second intervals of Saturn flight time for Cape Kennedy profiles was found to be log-normal. Maximum absolute gusts increased with altitude for altitudes from 4 to 15 km. The distribution of spectrum densities of gusts computed at frequencies from 0.3 to 3 cps for 900 Cape Kennedy profiles decreases with increasing frequency at a rate proportional to the -2.9 power of frequency for frequencies from 0.6 to 2.1 cps; at frequencies greater than 2.1 cps, a power law relation is not supported by the results. When spectrum densities were grouped with respect to deciles of wind speed and various wind shears, they showed a tendency to be larger at the high deciles. A preliminary study of a method for mathematical representation of observed gust functions suggests that the method can be applied to Jimsphere wind profiles that are closely spaced in time. Steady state winds for 794 Cape Kennedy profiles that were complete between 4 and 15 km, computed by subtraction of the gust component from the total wind, were in good agreement with the annual wind speeds of the Atlantic Missile Range Reference Atmosphere for the 50 percent cumulative frequency, but were significantly smaller for the 90, 95, 97.7 and 99 percent cumulative frequencies. A study of the climatological means and standard deviations of the magnitude of the vector shear at altitudes of 8 and 15 km indicates that they can be described by power law functions of layer thickness that are nearly alike for Cape Kennedy and Point Mugu, but are significantly different from those derived from a few summer profiles by other workers. A method for profile sampling is developed which provides profile sample sets that represent 5 critical characteristics of the parent population. A test of the method consisting of a comparison of the distributions of spectrum densities between 0.3 and 3.0 cps of 5 sample sets, each composed of 25 profiles, to the corresponding distributions of the entire population indicated that the spectrum distributions of any of the 5 sample sets offer a fair approximation to that of the whole 900 profile parent population. |  |                                              |                            |                                                                                                    |  |
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## FOREWORD

This report was prepared by the Lockheed-California Company, Burbank, California for the National Aeronautics and Space Administration, George C. Marshall Space Flight Center, Huntsville, Alabama under Contract NAS 8-30165. The contract title is "Further Study of Jimsphere Wind Profiles Related to Space Vehicle Design and Operations".

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The principal sections of this report were contributed by the following Lockheed-California Company (Calac) personnel and consultants: Dr. Stanley I. Adelfang (Calac), Sections 2 and 4; Dr. Arnold Court (Consultant) with Mr. Craig A. Melvin (Calac), Section 3; and Mr. Mohsen Pazirandeh (Consultant), Section 5.

## ABSTRACT

Statistical characteristics of steady state winds, gusts and wind shears observed over Cape Kennedy, Florida and Point Mugu, California with Jimsphere balloon sensors are described. Gusts in Jimsphere wind profiles as viewed in the time coordinates of a Saturn vehicle were isolated from the original profiles with a 33 weight digital high pass filter with negligible transmission of wind fluctuations at frequencies less than 0.15 cps. The distribution of gust variance computed for three ten second intervals of Saturn flight time for Cape Kennedy profiles was found to be log-normal. Maximum absolute gusts increased with altitude for altitudes from 4 to 15 km. The distribution of spectrum densities of gusts computed at frequencies from 0.3 to 3 cps for 900 Cape Kennedy profiles decreases with increasing frequency at a rate proportional to the  $-2.9$  power of frequency for frequencies from 0.6 to 2.1 cps; at frequencies greater than 2.1 cps a power law relation is not supported by the results. When spectrum densities were grouped with respect to deciles of wind speed and various wind shears they showed a tendency to be larger at the high deciles.

A preliminary study of a method for mathematical representation of observed gust functions suggests that the method can be applied to Jimsphere wind profiles that are closely spaced in time.

Steady state winds for 794 Cape Kennedy profiles that were complete between 4 and 15 km, computed by subtraction of the gust component from the total wind, were in good agreement with the annual wind speeds of the Atlantic Missile Range Reference Atmosphere for the 50 percent cumulative frequency but were significantly smaller for the 90, 95, 97.7 and 99 percent cumulative frequencies.

A study of the climatological means and standard deviations of the magnitude of the vector shear at altitudes between 8 and 15 km indicates that they can

be described by power law functions of layer thickness that are nearly alike for Cape Kennedy and Point Mugu but are significantly different from those derived from a few summer profiles by other workers.

A method for profile sampling is developed which provides profile sample sets that represent five critical characteristics of the parent population. A test of the method consisting of a comparison of the distributions of spectrum densities between 0.3 and 3.0 cps of five sample sets, each composed of 25 profiles, to the corresponding distributions of the entire population indicated that the spectrum distributions of any of the five sample sets offer a fair approximation to that of the whole 900 profile parent population.

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## Section 1

### INTRODUCTION

The characteristics of wind fluctuations that are important in space vehicle design and operation must be known with sufficient accuracy to assure a minimum risk of critical elastic and control mode responses. The development and use of roughened super-pressure (Jimsphere) balloons with minimal self induced motions that are tracked with advanced radar systems represents a significant advance towards increasing the accuracy of routine measurements of the horizontal vector wind as a fluctuation of altitude. The 119<sup>4</sup> Jimsphere profiles taken over Cape Kennedy, Florida between Nov. 1964 and May 1967, were the subject of a detailed study by Adelfang, Ashburn, and Court (Ref. 1). Two aspects of that study which are further developed in this report are the analysis of gust profiles computed from Jimsphere wind profiles expressed as a function of Saturn vehicle time coordinates (Section 2) and the study of the magnitude of the vector wind shear over various layer thicknesses (Section 4); the later study includes a set of 83 Jimsphere profiles taken over Point Mugu, California. The principal aim of these studies has been to derive, from the entire set of available profiles, statistical characteristics that are useful for space vehicle design and operation. However, in addition, it is often desirable to have the capability of selecting a relatively small sample of profiles which represent the critical characteristics of the large parent sample; in Section 3, a set of critical and test characteristics are suggested and a methodology is described and tested for selecting profile sub-sets.

In Section 5 a preliminary study is presented of a method for representing gust functions observed in Jimsphere wind profiles. The theory and original application of the method by Dutton (Ref. 2) and its application to groups of Jimsphere profiles closely spaced in time are discussed.

## Section 2

### ANALYSIS OF GUSTS DERIVED FROM JIMSPHERE WIND PROFILES TRANSFORMED TO VEHICLE TIME COORDINATES

#### 2.1 INTRODUCTION

Past analyses of Jimsphere profiles have resulted in the derivation of statistics which are valid for wind fluctuations described in altitude coordinates; for example Endlich et al, (Ref. 3 ) who studied three profile sequences, each composed of 4-6 profiles, found that there are no consistent or well-defined spectrum peaks that indicate natural separations between scales of motion and that the power spectrum density decreases with increasing frequency at a rate proportional to the -2.5 to -3 power. Although these and other similar results are interesting from a meteorological point of view they are not strictly applicable in describing the wind fluctuations that are seen by an accelerating space vehicle. For this study, 900 Cape Kennedy Jimsphere wind profiles were used as basic data for an analysis of wind fluctuations as viewed by a Saturn vehicle.

#### 2.2 GUST PROFILE DEFINITION

The frequency response of space vehicles to wind fluctuations is a function of control and structural mode characteristics which are nearly uniform for a particular class of vehicles. These vehicle response characteristics are usually defined in terms of temporal frequency,  $f$  (cps), rather than spatial frequency,  $K$  (cycles per meter, cpm). As a vehicle ascends with vertical velocity,  $v(t)$ , through the atmosphere, wind fluctuations at spatial frequency,  $K$ , are seen by the vehicle at frequency,  $f$ , given by

$$f = K v(t) \quad (2.1)$$

Thus, for example, the fluctuations in the wind profile at  $K = 2.74 \cdot 10^{-3}$  (cpm) as seen by a Saturn vehicle increase from  $f = 0.534$  cps at 4 km ( $v = 195$  m/sec) to  $f = 1.00$  cps at 12 km ( $v = 365$  m/sec). Since the first bending mode frequency of a Saturn 5 vehicle is approximately 1 cps the fluctuations at  $K = 2.74 \cdot 10^{-3}$  (cpm) are more important at 12 km than at 4 km. It is obvious that innumerable spatial frequencies exist for a particular critical value of temporal vehicle response frequency. Therefore it is necessary to transform the spatial fluctuations of wind profiles to temporal fluctuations as seen by the vehicle.

The general procedure suggested by Adelfang, Ashburn, and Court (Ref. 1 ) for deriving gust profiles is used for this study of Jimsphere wind profiles. The principal steps in the derivation are the transformation of Jimsphere profiles to a vehicle time coordinate system, definition of the wind fluctuations of interest, and digital high pass filtering.

Jimsphere wind profiles were transformed to vehicle time coordinates by evaluating them at altitudes,  $Z$ , (km.) corresponding to the time,  $t$  (sec), from launch at intervals of time,  $\Delta t$  (sec), according to the least squares quadratic fit to the Saturn AS-504 trajectory given by Jacobs (Ref. 4 ).

$$Z = 2.98416 - 0.14889 t + 0.00330 t^2 \quad (2.2)$$

$Z$  calculated from Equation 2.1 deviates less than 1.7% from the AS-504 trajectory for the time interval from 50 to 95 seconds ( $Z = 3.855$  to  $18.530$  km). The time interval  $\Delta t$  was chosen small enough to include all Jimsphere data up to 17.2 km. Assuming that a Jimsphere profile contains independent estimates of wind over 75m altitude intervals, the time interval,  $\Delta t$  (sec), between independent wind estimates as seen by a vehicle is  $75/v(t)$ ; at 17.2 km, for Saturn AS-504,  $v(t) = 450$  m/sec and thus  $\Delta t = 1/6$  second.

The transformed wind profile is an approximation of the profile "seen" by the vehicle; the accuracy of the approximation for space vehicle studies is

not yet known and may only be determined when the statistics of vehicle responses derived from simulated flights through Jimsphere wind profiles are compared to the same statistics derived from wind profile data obtained from sensors which traverse the atmosphere in space-time coordinates that are similar to those of space vehicles.

The fluctuations of interest which will be referred to as gusts are characterized by their influence on space vehicle control and structural excitation frequency modes. For a Saturn vehicle significant response to wind fluctuations occur at the control frequency ( $\sim 0.2$  cps) and at the first and second bending mode frequencies ( $\sim 1, 2$  cps). Wind profiles which have fluctuations at frequencies  $\geq 0.2$  cps are defined as gust profiles. Gust profiles were calculated by application of a 33 weight digital high pass filter which has a transfer function of the form

$$H(f) = 1 - e^{-\left[f/f_s(.0255)\right]^2} \quad (2.3)$$

where  $f$  = frequency (cps)

Since  $f_s$ , the data sampling frequency is  $6 \text{ sec}^{-1}$  Equation (2.3) reduces to

$$H(f) = 1 - e^{-(6.535 f)^2} \quad (2.4)$$

The 33 point weighting function (listed in Table 2.1) for the high pass filter was calculated by subtracting the weighting function of the low pass filter described by Alfriend (Ref. 5) from the weighting function of an all pass filter (an all pass filter has weights equal to zero except for the middle weight which is unity). The transfer function of the Alfriend low pass filter for  $f_s = 6 \text{ sec}^{-1}$  is

$$H(f) = e^{-(6.535 f)^2} \quad (2.5)$$

The transfer functions of the high and low pass filters described by Equations 2.4 and 2.5 are illustrated in Figure 2.1.



TABLE 2.1  
33 WEIGHT DIGITAL HIGH PASS FILTER  
WITH TRANSFER FUNCTION GIVEN BY  
EQUATION 2.4;  $\Delta t = 1/6$  SEC.

| TIME                        | NUMERICAL WEIGHTS |
|-----------------------------|-------------------|
| t                           | 0.951844          |
| $-\Delta t, + \Delta t$     | -0.047848         |
| $-Z\Delta t, + Z\Delta t$   | -0.046936         |
| •                           | -0.045453         |
| •                           | -0.043457         |
| •                           | -0.041013         |
| •                           | -0.038222         |
| •                           | -0.035162         |
| •                           | -0.031935         |
| •                           | -0.028634         |
| •                           | -0.025346         |
| •                           | -0.022151         |
| $-n\Delta t, + n\Delta t$   | -0.019110         |
| •                           | -0.016288         |
| •                           | -0.013689         |
| •                           | -0.011364         |
| $-16\Delta t, + 16\Delta t$ | -0.009314         |

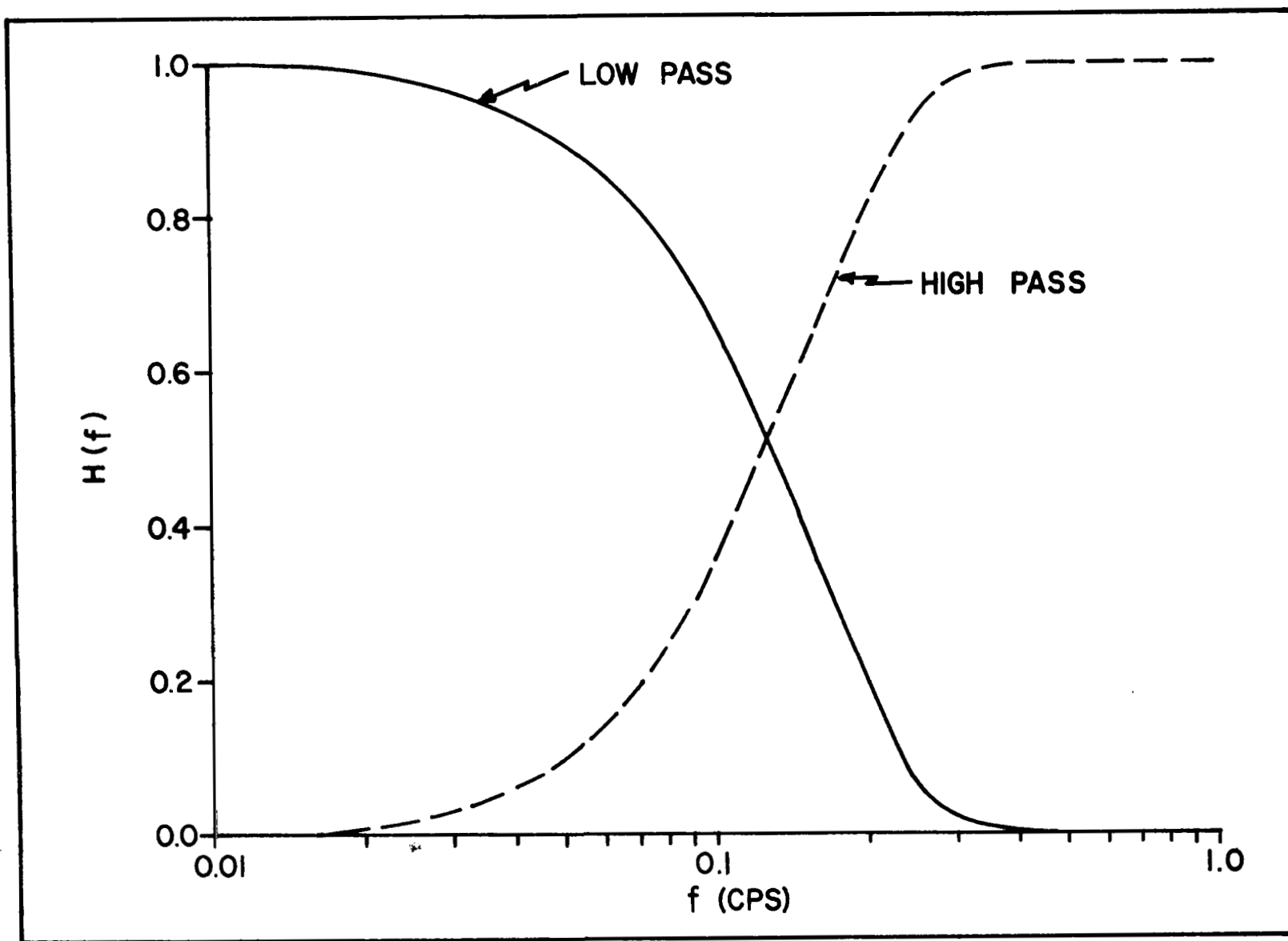


Figure 2.1 Transfer Function of Alfriend Exponential Low and High Pass Filters for a Sampling Frequency of 6/sec.

The relation between the low and high pass filtered profile and the total profile is illustrated in Figure 2.2 for Cape Kennedy Jimsphere profile # 477; the total profile transformed to Saturn AS-504 time coordinates is represented by the solid line; the low frequency or low pass filtered profile which has been termed the steady state wind profile with respect to the Saturn AS-504 in Reference 1 is illustrated by the dashed line; the gust or high pass filtered profile which is the total profile minus the low pass filtered profile is illustrated across the top of the figure.

## 2.3 STATISTICAL ANALYSIS

### 2.3.1 Introduction

The Cape Kennedy Jimsphere wind speed profiles, each decomposed into a low frequency steady state component and a high frequency gust component according to the method described in the previous section, were analyzed to determine the distribution of, gusts and steady state winds as a function of altitude, gust variance as a function of Saturn AS-504 flight time interval, and the power spectrum densities (PSD) of gusts. The distribution of PSD's of gusts were computed for 900 profiles that were complete between 1 and 14 km. The distribution of PSD's were also computed for sub-sets of 90 profiles associated with the deciles of maximum wind speed and maximum 100, 400, 1,000 and 3,000 m vector shears (for winds increasing with height) computed for each of the 900 profile parent population. Additional PSD calculations used to verify the technique for selecting representative profile sub-sets are presented in Section 3.

### 2.3.2 Distribution of Steady State Wind Speeds, Gusts, and Gust Variance

The percentile distributions of steady state wind speeds and gusts as a function of altitude are illustrated in Figures 2.3 and 2.4. The percentiles were computed for the 794 profiles which had steady state and gust data between 4 and 15 km. The percentiles are plotted at altitude intervals of

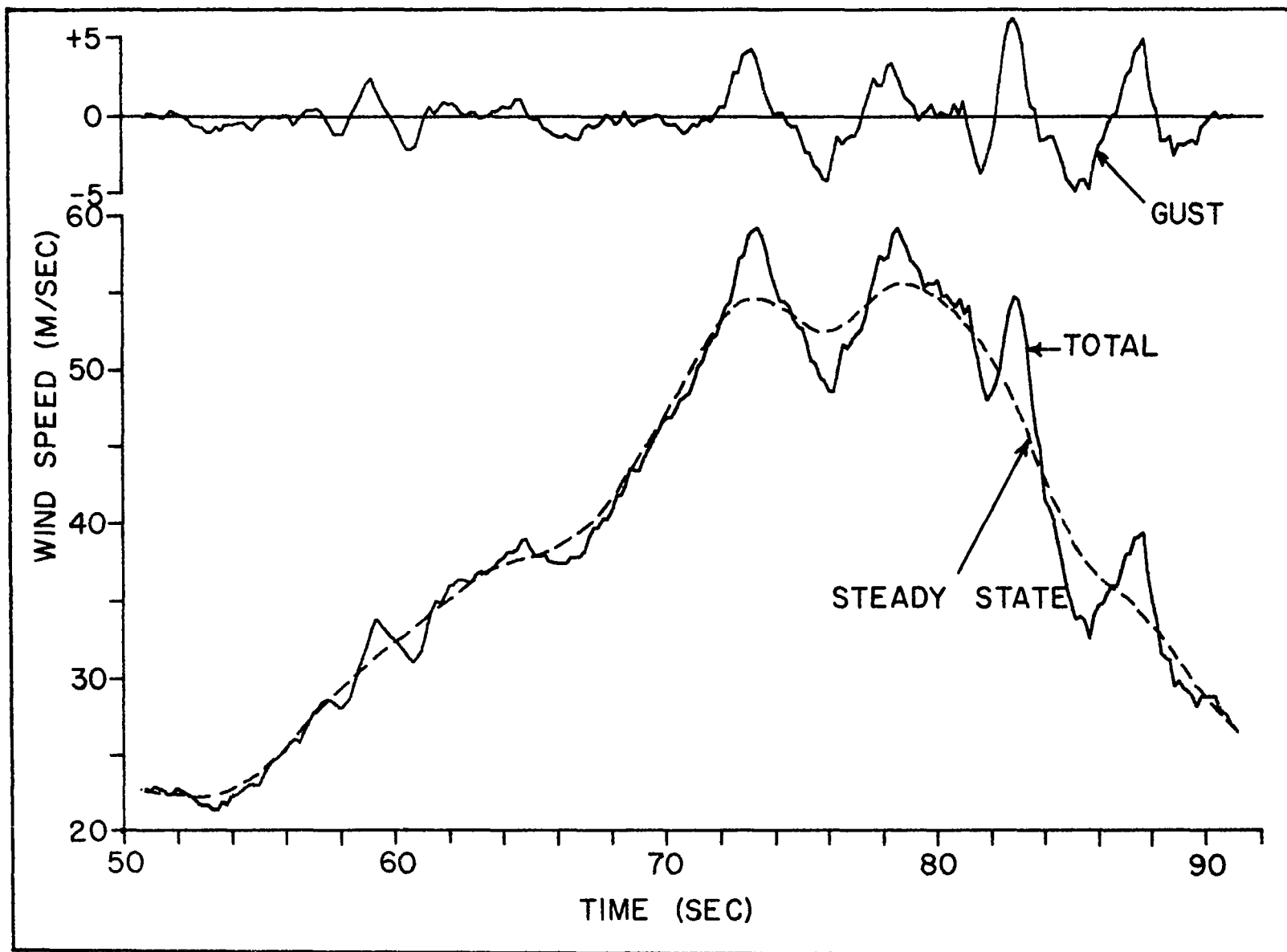


Figure 2.2 Jimsphere Wind Profile No. 477, Transformed to Saturn AS-504 Time Coordinates (Solid Line), Steady State (Dashed Line) and Gust as Labeled.

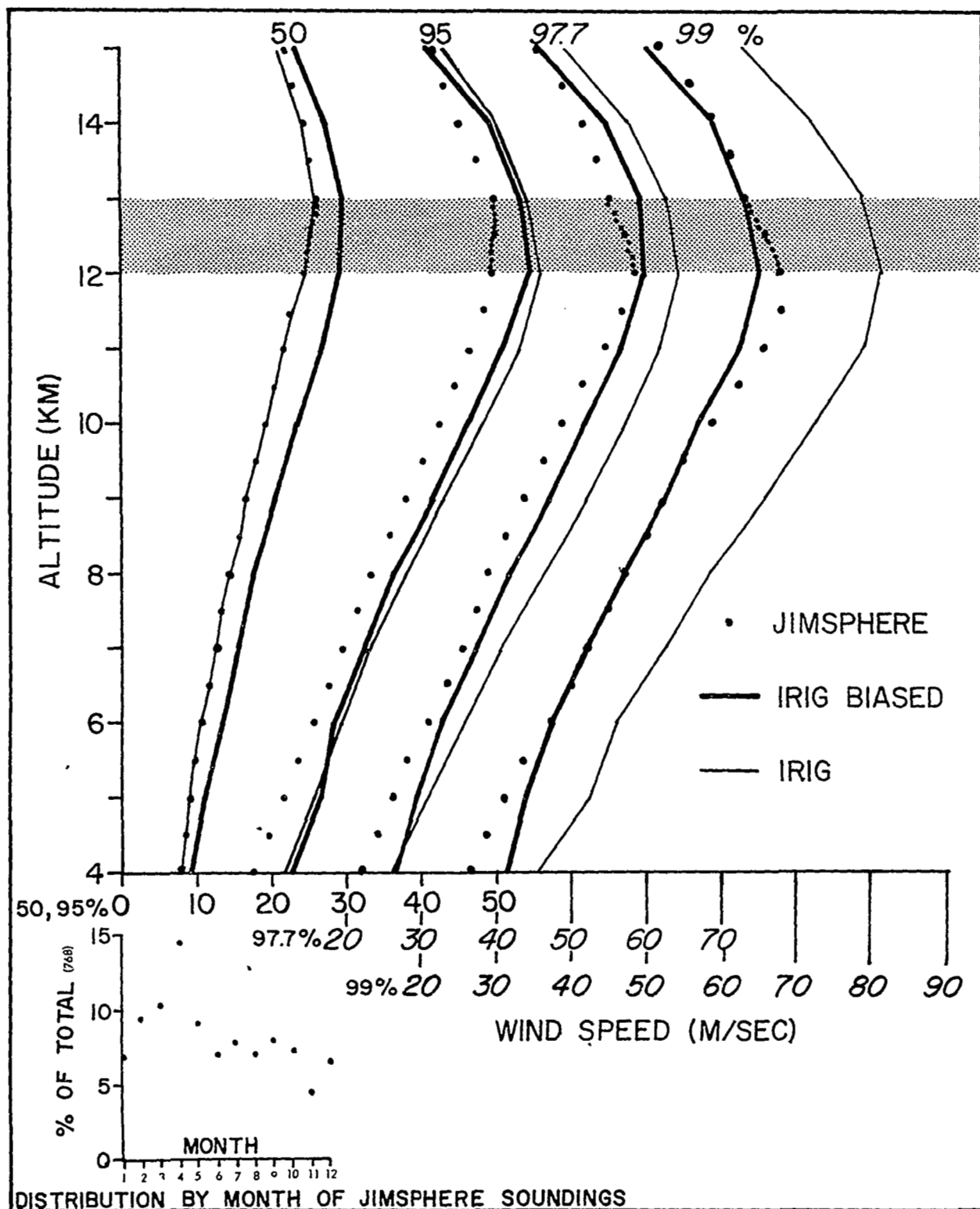


Figure 2.3 Distribution of Steady State Winds as a Function of Altitude Computed from 794 Cape Kennedy Jimsphere Profiles; at Lower Left Distribution by Month of the 794 Profiles Used; Also Illustrated are the Annual and Biased Annual IRIG Wind Speeds for Cape Kennedy (Ref. 5 ).

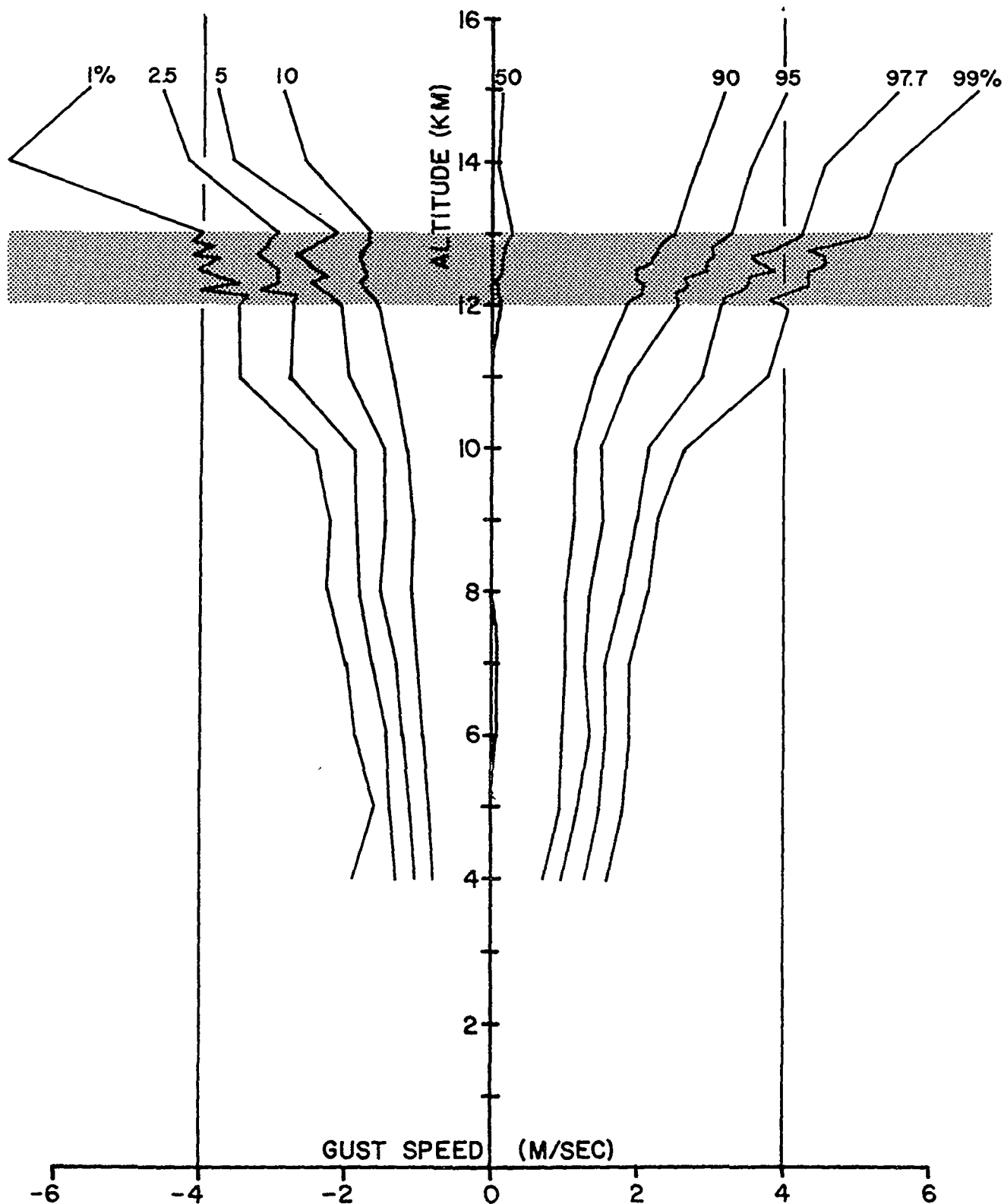


Figure 2.4 Distribution of Gusts as a Function of Altitude Computed from 794 Cape Kennedy Jimsphere Profiles; the Distribution by Month of the 794 Profiles is Illustrated in Figure 2.3

1 km between 4 and 15 km, and 100 m between 11 and 12 km. Also illustrated in Figure 2.3, for comparison, are the 50, 95, 99.7 and 99% annual scalar wind speeds of the IRIg reference atmosphere (Ref. 6 ) which were derived from 4,384 Rawinsonde profiles over Cape Kennedy. As illustrated the steady state winds derived from Jimsphere profiles increase with increasing altitude above 4 km attaining a maximum at an altitude of 12.9 km for 50%, 12.0 km for 95%, 12.1 km for 97.7% and < 12 km for 99%. The 95, 97.7 and 99 percentile steady state winds computed from Jimsphere wind profiles are systematically smaller than the wind speeds of the IRIg standard atmosphere. As illustrated in Figure 2.3, the distribution of the 794 Jimsphere profiles by month is non-uniform with a large peak for April thus introducing a bias in the annual distribution. However, when biased annual IRIg wind speed percentiles, computed by taking an average of the monthly values weighted according to the number of Jimsphere soundings for a particular month, are compared to the Jimsphere distribution the same qualitative conclusions stated above for the comparison to the unbiased IRIg atmosphere are valid for the 95 and 97.7 percentiles; however at altitudes between 10 and 15 km the biased IRIg 99% wind speeds are as much as 5% less than the Jimsphere steady state winds. At the 50 percentile there is good agreement between Jimsphere and IRIg annual whereas the IRIg biased annual is substantially larger than the Jimsphere steady state winds. Thus by biasing the IRIg distribution the correspondance between IRIg and Jimsphere was generally improved at the extreme percentiles and degraded at the median.

As illustrated in Figure 2.4 the gust magnitudes at the extreme percentiles ( $\geq 90\%$ ,  $\leq 10\%$ ) generally increase with altitude; the variability of gust magnitudes for small scale variations of altitude is illustrated by the data given at 100 m intervals between 12 and 13 km. The maximum observed absolute gust speed ( $G_{\max}$ , m/sec) as a function of altitude (km) is illustrated in Figure 2.5; the solid line in the figure is the least squares quadratic function fitted to the data

$$G_{\max} = 2.90 - 0.30Z + 0.05Z^2 \quad (2.6)$$

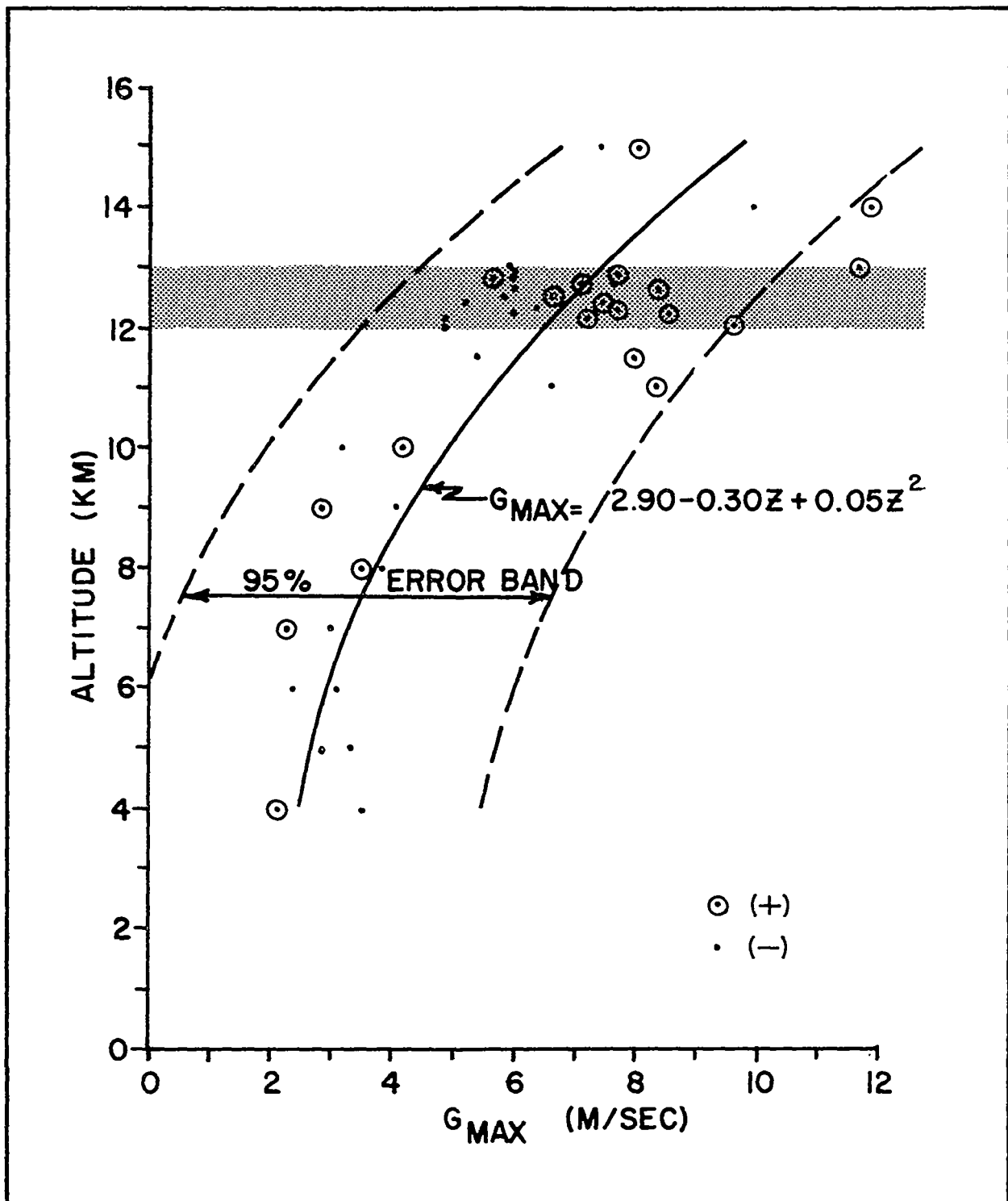


Figure 2.5 Maximum Observed Absolute Gust Speed as a Function of Altitude in 794 Cape Kennedy Jimsphere Profiles



Figure 2.6 illustrates the cumulative percentile distribution of gust variance ( $m^2/sec^2$ ) for three Saturn vehicle flight time intervals of 60-70, 70-80 and 80-90 seconds; these time intervals correspond to Saturn altitude intervals of 5.93 to 8.73, 9.73 to 12.19, and 12.19 to 16.31 km respectively. The cumulative distribution is approximately log-normal as indicated by the straight lines fitted to the plotted points.

### 2.3.3 Power Spectrum Densities of Gusts

Power spectrum densities (PSD's) of 900 Jimsphere gust profiles defined in the time domain of a Saturn vehicle were computed according to the method described by Blackman and Tukey (Ref. 7). The 900 profiles were selected on the basis of completeness between 4 and 14 km. A Saturn vehicle in an AS-504 trajectory requires 36 seconds to traverse the 4 to 14 km altitude interval; thus a gust profile evaluated at 1/6 second intervals according to Equation 1 would contain 216 data points. PSD's, computed using 10 lags, are given at intervals of 0.3 cps from 0.3 to 3.0 cps. The cumulative percentile distribution of the PSD's  $\left[ (M/sec)^2 / \text{cycle/sec} \right]$  at each frequency is given in Table 2.2.

In Figure 2.7 the PSD's at the median and the 95 and 99 percentiles are compared with recent updated MSFC design criteria spectra (Ref. 8) derived in the altitude domain from a similar set of Cape Kennedy Jimsphere wind profiles. The direct comparison is valid only if the MSFC PSD's,  $\Phi(K) \left[ (M/sec)^2 / (\text{cycle}/4,000 \text{ m}) \right]$ , originally expressed as a function of spatial frequency,  $K$  (cycles/4,000 m) can be transformed to PSD's in the time domain of vehicle flight,  $\Phi(f) \left[ (M/sec)^2 / (\text{cycle/sec}) \right]$  according to the simple relation, implied by Ryan et al, (Ref. 9),

$$\Phi(f) = \frac{4 \times 10^3 \Phi(K)}{v} \quad (2.7)$$

where  $v$  is a vehicle vertical velocity arbitrarily chosen at the altitude

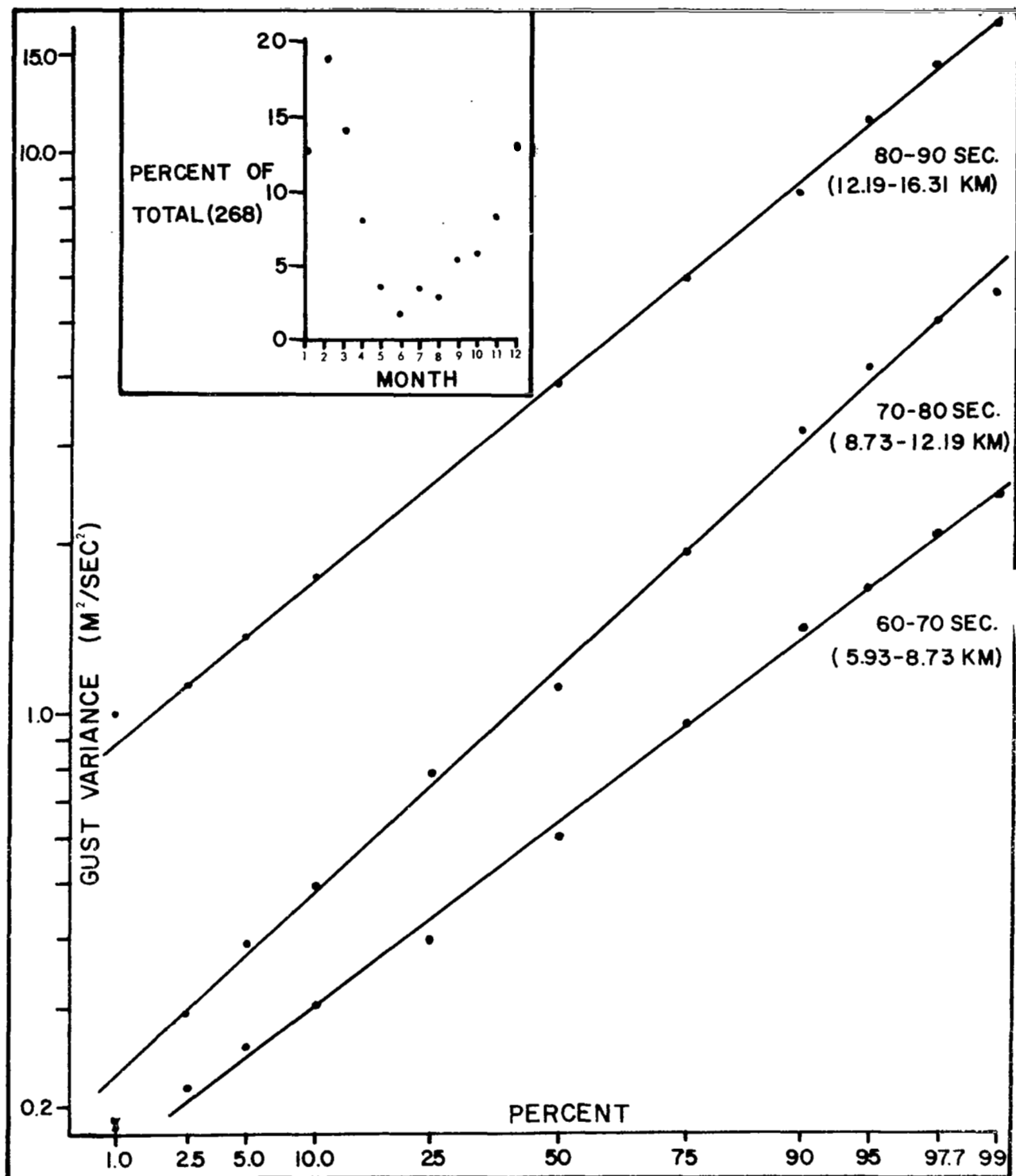


Figure 2.6 Cumulative Distribution of Gust Variance Computed for 268 Jimsphere Profiles for Three 10 Second Intervals of Saturn AS-504 Flight Time; at Upper Left is Distribution by Month of 268 Profiles Used

| FREQUENCY<br>(CPS) | PSD [(M/SEC) <sup>2</sup> /(CYCLE/FT)] |        |        |        |            |        |               |        |        |        |        |        |        |
|--------------------|----------------------------------------|--------|--------|--------|------------|--------|---------------|--------|--------|--------|--------|--------|--------|
|                    | MIN.                                   | 1.0    | 2.3    | 5.0    | CUMULATIVE |        | FREQUENCY (%) |        | 90.0   | 95.0   | 97.7   | 99.0   | MAX.   |
| 0.3                | 2.3728                                 | 0.5535 | 0.6612 | 0.7731 | 0.9057     | 1.3092 | 1.9327        | 2.6919 | 3.5582 | 4.4052 | 5.2680 | 5.7102 | 7.9160 |
| 0.6                | 3.1365                                 | 0.1583 | 0.1975 | 0.2317 | 0.2780     | 0.3672 | 0.5123        | 0.6993 | 0.8798 | 1.0055 | 1.1828 | 1.3697 | 1.7266 |
| 0.9                | 0.0490                                 | 0.0525 | 0.0690 | 0.0813 | 0.0941     | 0.1199 | 0.1613        | 0.2164 | 0.2620 | 0.2983 | 0.3358 | 0.3650 | 0.6652 |
| 1.2                | 0.0202                                 | 0.0243 | 0.0303 | 0.0351 | 0.0402     | 0.0526 | 0.0690        | 0.0896 | 0.1172 | 0.1345 | 0.1537 | 0.1760 | 0.3916 |
| 1.5                | 0.0107                                 | 0.0150 | 0.0166 | 0.0185 | 0.0212     | 0.0285 | 0.0374        | 0.0510 | 0.0681 | 0.0868 | 0.1022 | 0.1374 | 0.1941 |
| 1.8                | 0.0063                                 | 0.0079 | 0.0097 | 0.0103 | 0.0127     | 0.0175 | 0.0237        | 0.0332 | 0.0497 | 0.0658 | 0.0837 | 0.1066 | 0.1583 |
| 2.1                | 0.0037                                 | 0.0052 | 0.0059 | 0.0077 | 0.0085     | 0.0114 | 0.0161        | 0.0241 | 0.0381 | 0.0554 | 0.0718 | 0.1024 | 0.1453 |
| 2.4                | 0.0021                                 | 0.0037 | 0.0043 | 0.0052 | 0.0061     | 0.0082 | 0.0120        | 0.0185 | 0.0309 | 0.0453 | 0.0676 | 0.0959 | 0.1621 |
| 2.7                | 0.0014                                 | 0.0029 | 0.0035 | 0.0044 | 0.0049     | 0.0066 | 0.0098        | 0.0157 | 0.0269 | 0.0412 | 0.0619 | 0.0896 | 0.1703 |
| 3.0                | 0.0013                                 | 0.0023 | 0.0026 | 0.0032 | 0.0041     | 0.0067 | 0.0093        | 0.0144 | 0.0267 | 0.0384 | 0.0578 | 0.0904 | 0.1555 |

Table 2.2 Cumulative Distribution of Power Spectrum Densities of 900 Jimsphere Profiles

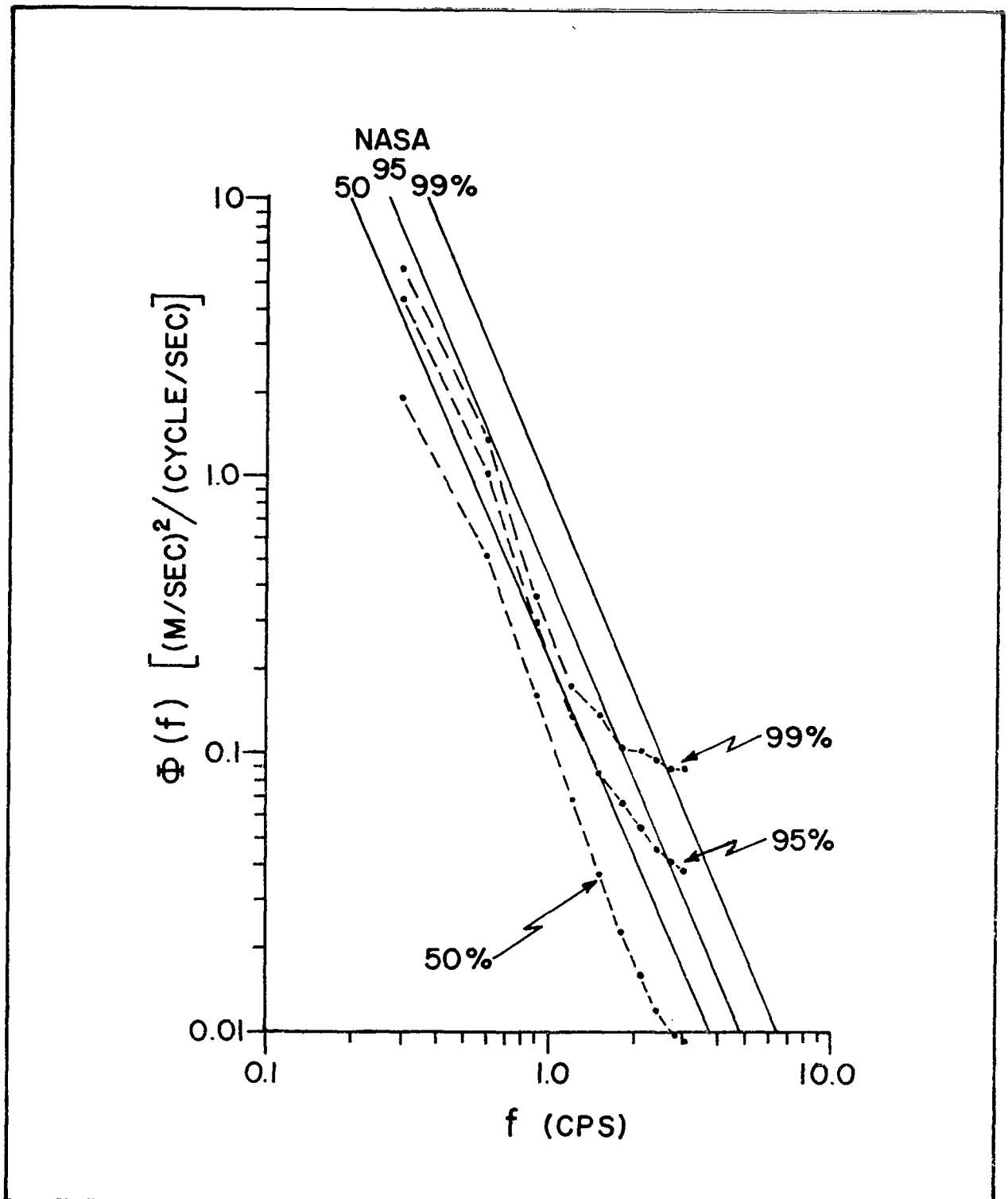


Figure 2.7 Median and 95 and 99% Upper Bounds of Power Spectrum Densities of 900 Jimsphere Wind Speed Gust Profiles from 4 to 14 km Over Cape Kennedy Computed in the Vehicle Time Domain (dots) and MSFC Design Spectra Bounds Computed in Altitude Domain and Transformed to Vehicle Time Domain (lines)

of maximum dynamic pressure, 12 km; for a Saturn vehicle  $v$  is 350 m/sec at 12 km and thus,

$$\bar{\Phi}(f) = 11.4 \bar{\Phi}(K) \quad (2.8)$$

similarly  $f$  (cps) is a function of  $K$ ,

$$f = \frac{Kv}{4.10^3} = 0.0875 K \quad (2.9)$$

As illustrated in Figure 2.7 the PSD's at the 50 percent level for the MSFC design spectra are larger by a factor of 1.5 to 2 at all frequencies when compared to the PSD's computed from vehicle time domain profiles; similarly at the 95 and 99 percent level for  $f \leq 1.5$  cps the MSFC design spectra are larger by factors of 1.4 to 1.7 and 2.2 to 2.7 respectively; for  $f > 1.5$  cps the PSD's at the 95 and 99 percent level for the vehicle time domain profiles decrease at a slower rate with increasing  $f$  and thus each are larger than the MSFC PSD's for  $f > 2.5$  cps. These comparisons illustrate an apparent difference between spectra of profiles expressed in vehicle time coordinates and spectra of profiles in altitude coordinates; however the transformation of the spectra from one coordinate system to the other implied by Equations 2.8 and 2.9 is strictly valid only when  $v$  is not a function of altitude; when  $v$  is a function of altitude comparison of the spectra is not possible because a simple transformation does not exist. Therefore the data given in Table 2.2 represent the best estimates, based on Jimsphere profiles, of the distribution of PSD at various frequencies as viewed by a Saturn vehicle; other estimates based on transformation of altitude domain spectra to the vehicle time domain [Equations 2.8 and 2.9] are not strictly comparable.

To study the relation of the distribution of PSD to the distribution of maximum wind speeds and maximum vector shears of 900 Jimsphere profiles, PSD's were computed from 50 sets of 90 profiles that are associated with the deciles (90 profiles per decile for a set 900 data values) of maximum wind speed and maximum 100, 400, 1,000, and 3,000 m. vector shear for wind speeds increasing with altitude (as indicated by (+) sign). The 50, 95, and 99% PSD at 0.3, 0.6, 1.2, and 2.4 cps, plotted as a function of decile

for maximum wind speed and vector shears, are illustrated in the upper half of Figure 2.8. The tendency for the PSD to be larger at higher deciles of wind speed and shear is illustrated quantitatively in the lower half of Figure 8 in which the ratio of PSD at decile N ( $N = 1, 2, \dots, 10$ ) to PSD at decile 1 [ $\text{PSD}(N) / \text{PSD}(1)$ ] is plotted as a function of decile N.

The decile limits used in this analysis are given in Table 3.2 (Page 28)

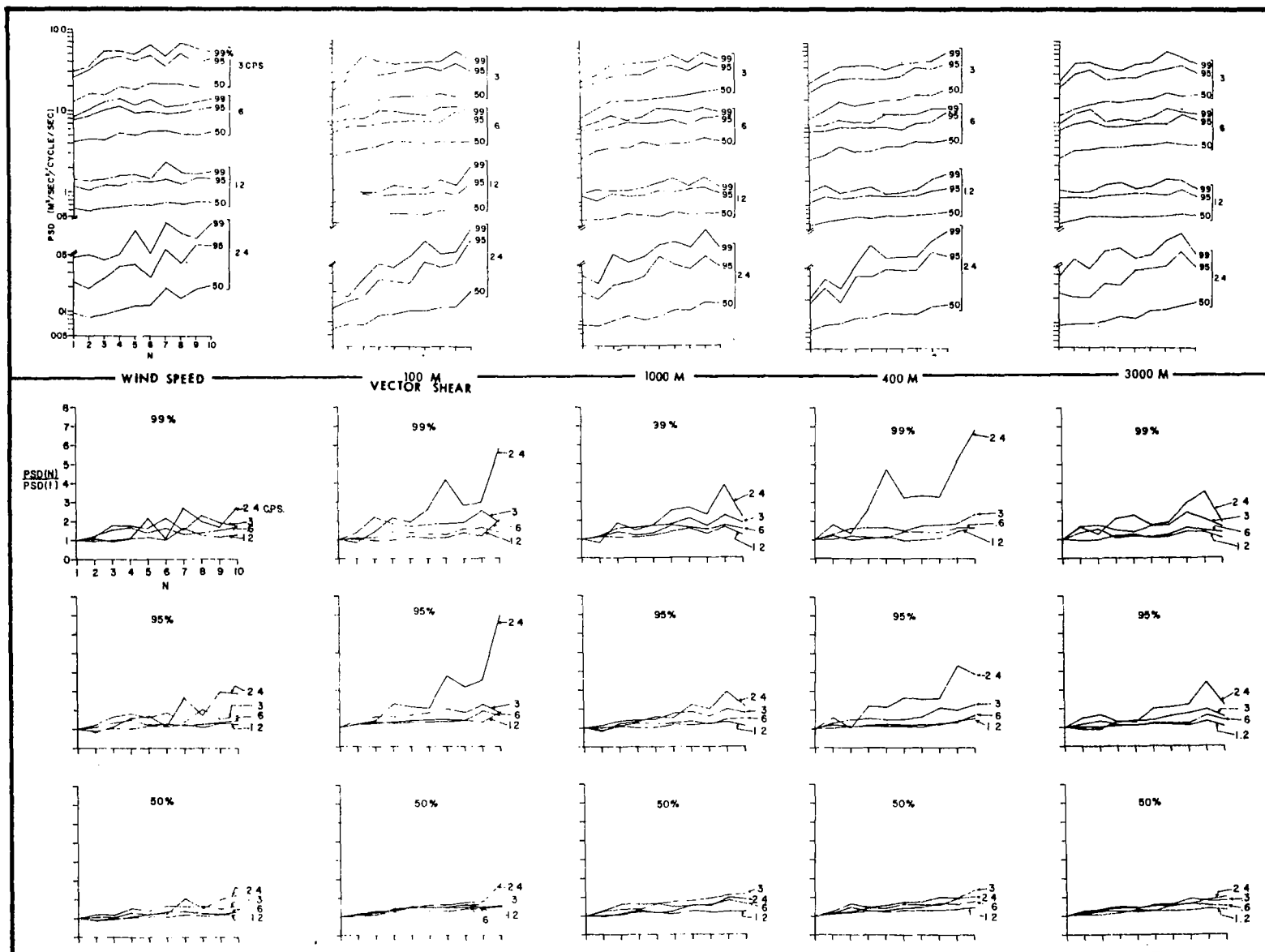


Figure 2.8 Upper Half: Median 95 and 99% Upper Bounds of PSD of Jimsphere Wind Speed Gust Profiles Associated with Deciles (90 Profiles per Decile) of Maximum Wind Speed and Maximum 100, 400, 1,000, and 3,000m Vector Shears; Lower Half: Ratio of Median, 95 and 99% Upper Bounds of PSD at Decile N (N = 1, 2 . . . 10) to PSD at Decile 1.

## Section 3

### WIND PROFILE SAMPLING

#### 3.1 PROFILES

Wind profiles represent the variations with height of the horizontal motions of the atmosphere. In principle, a wind profile is a vector function of height, representing the variation of both the speed and the direction of the air movement, or wind. In practice, however, the variation of wind in the vertical usually is represented by two separate profiles, either for speed and direction or for the magnitudes of two orthogonal wind components. In this report, a method is offered for obtaining a representative sample of profiles from a collection of several hundred (or more) profiles, using order statistics.

Although profiles over a fixed point vary continuously in time, they are obtained routinely only every 6 or 12 hours at major weather stations; occasionally, research or operational requirements provide several consecutive wind observations, from which profiles can be obtained, at hourly intervals, or even more frequently. Horizontal air motion varies continuously with height, but instrumental and computational problems preclude obtaining wind information at intervals of less than 50 meters, usually much more. Routine upper wind information is available only at 1 km intervals, every 12 hours. Even so, in ten years more than 7,300 wind profiles accumulate for each station. For the entire United States during the 1960s, more than 1.5 million profiles were obtained, from the surface to heights of 30 km or more.

Wind profiles must be used in the formulation and testing of designs for vehicles intended to ascend or descend rapidly through the atmosphere, traversing layers in which the air motion may come from widely differing directions at highly variable speeds. But no engineer can hope to use all 1.5 million profiles in developing a new vehicle, or even the thousands available for the specific site from which the vehicle will be launched.



Some method of averaging or otherwise characterizing the profiles must be used.

Straight averages of wind speed and direction, level by level, are available, but are of little use to engineers. Their vehicles are most susceptible to the extremes, not the means, and in particular to the changes of wind with height. The difference between winds at two levels in the vertical shear of the horizontal wind. The difference between speeds of the wind at two levels, regardless of directions, is the scalar shear; the difference between the two wind vectors (involving both speed and direction) is the vector shear, which has both direction and magnitude.

Scalar shear may be positive (speed increasing with height) or negative, but the magnitude of vector shear is always positive. However, strong winds do not change much in direction with height, so very large vector shear magnitudes are virtually equivalent to the absolute values of the corresponding scalar shears. To distinguish between vector shears according to whether the wind speed increases or decreases with height, the vector shears, in this report, are given the sign of the corresponding scalar shears.

### 3.2 CRITERIA

Wind profiles, available in profusion, must be summarized in some way for the design and testing of aerospace vehicles. Such summaries may be either in the form of statistics representing the entire collection of available profiles, or may be in the form of a few profiles, either actual or synthetic, selected so as to be typical, in some way, or the entire collection.

Many statistical summaries, to varying degrees of sophistication, have been prepared of available wind data. Typically, they are based on winds represented, for each level, by two orthogonal components, the zonal (west-to-east) and meridional (south-to-north). The summaries offer the means and standard deviations of each component at each level, usually 1 km apart, and matrices of correlation coefficients, both within-component and cross-

component.

Within-component correlations are between like components at different levels, so that for a set of  $n$  profiles, each offering data at  $k$  levels, two sets of correlations are computed, one for each component, for a total of  $k^2 - k$  coefficients. Cross-component correlations are between the zonal component at one level and the meridional component at that level as well as each of the other levels, and vice-versa; including the correlations at each of the  $k$  levels gives a total of  $k^2$  cross-component correlations. Thus a complete statistical summary (without considering possible serial correlation from one profile to the next) includes  $2k$  means,  $2k$  standard deviations,  $k^2 - k$  within-component correlations, and  $k^2$  cross-component correlations, or a total of  $3k + 2k^2$  numbers. When winds are available from the surface up to 20 km,  $k = 21$  and the complete statistical summary has 945 numbers.

A few wind profiles have been synthesized from statistical summaries, starting with an extreme wind speed at a level of maximum effect on a vehicle, and using correlations to determine the corresponding winds at other levels. The extreme wind usually is the mean wind speed plus two standard deviations, a value that would have been exceeded in less than 5% of the observations, if the wind speed were normally distributed. Even if such an assumption of normality were justified, the probability of the complete statistical profile cannot be established because of inter-dependence of the correlations.

The first profiles for design of missiles and space vehicles were less sophisticated. Essentially they were the observed profiles which included the strongest winds at the level of maximum effect. Variations on this approach included selection of not only the profiles containing the strongest winds but also those with the greatest wind shears above and below such winds.

Another approach was to calculate the actual effect induced upon a typical space vehicle by each of a great many profiles, and then selecting those profiles which produced the strongest effects. This sample was then presumed to be equally useful for other vehicles having responses to wind not greatly different from those of the typical vehicle.

The considerations inherent in these procedures have been used in the present study in a different way. From a large number of profiles, a sample is selected which has the same characteristics with respect to maximum wind speed and to wind shears over certain thicknesses.

### 3.3 PROFILE CODING

A wind profile represents wind speeds and directions (or strengths of two components) at many heights. From these values, wind shears for many thicknesses can be computed. While all of these quantities may be of some interest, only a few can be considered critical. After these critical characteristics are identified, from aerodynamic or other considerations, each profile can be classified according to them.

The critical characteristics, designated as  $c_1, c_2, \dots, c_j$ , may be, for example, the strongest wind at any level between 5 and 15 km, the greatest positive (speed increasing with height) vector wind shear over a 1 km layer within the same interval, the strongest negative 100 m shear, etc. Once these characteristics have been selected, values of each characteristic for the entire collection of profiles are assembled, and placed in rank order.

Thus, all the soundings are placed in sequence according to the magnitude of  $c_1$ , without regard to date or to any other characteristics. This ordering is then divided into equal numbers of soundings; for the present development, this number is taken as 10, but can be any other convenient number, such as 5 or 8 or 20. Then each profile is given an identifier according to the decile in which its value of  $c_1$  falls. The 10 percent of all the

profiles in which  $c_1$  is smallest receive a code number of 1, the next 10 percent are coded 2, and so up to the 10 percent with the largest values of  $c_1$ , which are coded as 10.

The same process is repeated for each of the other characteristics, so that each profile eventually has a sequence of code numbers, one for each characteristic. The numbers indicate in which decile the profile falls with respect to each critical characteristic, and permit the profiles to be sorted and classified in various ways, including selection of representative samples.

From the large collection of profiles, a sample may be drawn so that each decile of each characteristic is represented by at least  $m$  profiles. This criterion can be shown simply by an array, or matrix, in which the rows represent the characteristics and the columns the deciles (Table 3.1).

TABLE 3.1

SCHEMATIC OF DECILE CODING SCHEME

|       | Deciles |   |   |   |   |   |   |   |   |    |
|-------|---------|---|---|---|---|---|---|---|---|----|
|       | 1       | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| $c_1$ | .       | . | . | 1 | . | . | . | . | . | .  |
| $c_2$ | .       | . | . | . | 1 | . | . | . | . | .  |
| --    |         |   |   |   |   |   |   |   |   |    |
| $c_j$ | .       | 1 | . | . | . | . | . | . | . | .  |

In Table 3.1, a single profile with code 4 5 . . . 2 is indicated. As soundings are added to the sample, the number of profiles falling into each cell is tallied, and profiles are accepted until all cells have at least  $m$  entries.

Alternatively, an upper limit may be placed on the number of entries per cell. Profiles are added to the sample, one at a time, unless such addition would cause some cell to have more than the desired number,  $m$ . Such a profile is rejected, and the next one examined, with the process continuing until all cells have  $m$  entries - - or the entire collection is exhausted, with some cells still having less than  $m$  entries.

### 3.4 APPLICATION

To test this procedure for obtaining representative samples of wind profiles, five critical characteristics were established and a collection of 900 Jimsphere wind profiles were classified and sorted. These profiles represent winds observed at 50-meter intervals from the surface to 14 km over Cape Kennedy, Fla.; they were selected from a set of 1194 profiles obtained from 28 Nov. 1964 through 11 May 1967 by discarding all profiles with any missing data at any level from 1 to 14 km. The complete 1194-profile set was examined in detail by Adelfang, Ashburn, and Court (Ref. 1 ). More intensive study showed that 16 listed profiles actually had no data, and 11 were exact duplicates of previous profiles.

The five critical characteristics, restricted to the range from 4 to 14 km, were:

- $c_1$  : maximum wind speed at any level in the profile;
- $c_2$  : maximum "positive" vector shear over any 100-meter interval;
- $c_3$  : maximum "negative" vector shear over any 100-meter interval;
- $c_4$  : maximum "positive" vector shear over any 1 km interval;
- $c_5$  : maximum "negative" vector shear over any 1 km interval.

Thus, the lowest 100-meter shear considered was from 3900 to 4000 meters, while the lowest 1 km shear was from 3000 to 4000 meters. In several cases this definition caused the discarding of strong 100-meter shears below 4000 meters, while 1 km shears including this 100-meter shear were accepted.

Nevertheless these five characteristics were assumed to represent the major aspects of wind profiles of importance in space vehicle design. The sampling methodology would work equally well for other characteristics.

To test the representativeness of samples based on these five characteristics, four other vector shears were identified and coded by deciles for each profile; also only for shears for which the upper boundary was between 4 and 14 km:

- $c_6$  : maximum "positive" vector shear over any 400-meter interval;
- $c_7$  : maximum "negative" vector shear over any 400-meter interval;
- $c_8$  : maximum "positive" vector shear over any 3 km interval;
- $c_9$  : maximum "negative" vector shear over any 3 km interval.

These nine characteristics and their altitude of occurrence were identified in each of the 900 Jimsphere wind profiles, as shown in Appendix I. Each set of characteristics was then placed in rank order, and grouped into deciles. Limits of the deciles for each of the nine characteristics, for the 900 profiles, are given in Table 3.2 and graphed in Figure 3.1; various cumulative percentiles of the altitude of occurrence are also graphed in Figure 3.1. The only characteristic to have a lower limit of zero was the 3 km negative shear; actually, 41 profiles had no negative 3 km shears, indicating that these profiles, if smoothed by 3 km moving averages, would show winds continually increasing with height.

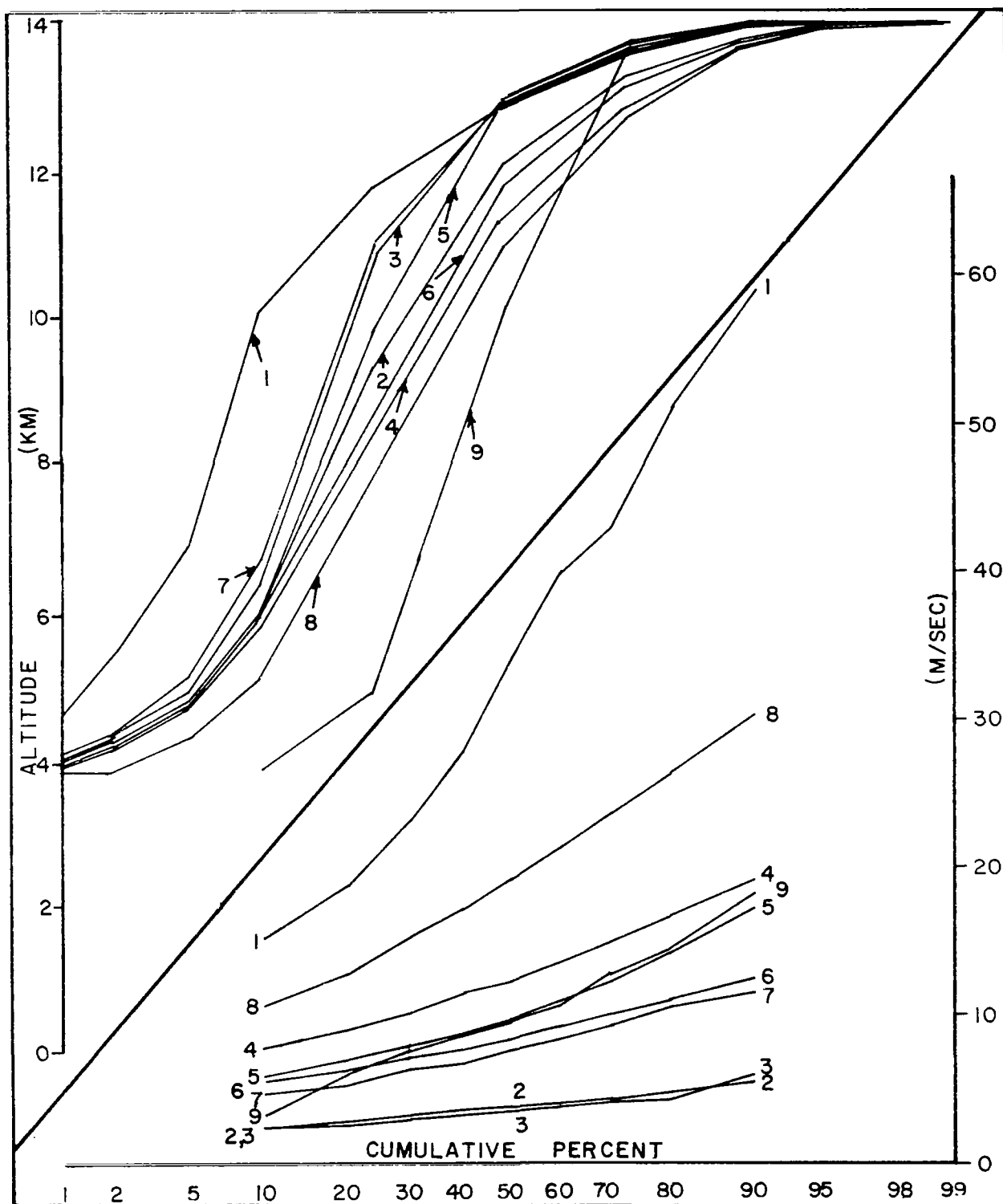


Figure 3.1 Cumulative Decile Limits and Percentiles of Corresponding Altitudes for 5 Selection Characteristics (1-5) and 4 Test Characteristics (6-9).

TABLE 3.2

LIMITS OF DECILES FOR EACH OF 9 CHARACTERISTICS OF  
900 JIMSPHERE PROFILES. UNITS ARE METERS PER SECOND.

| DECILE:        |     | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | X    |
|----------------|-----|------|------|------|------|------|------|------|------|------|------|
| LIMITS:        | MIN | 10   | 20   | 30   | 40   | 50   | 60   | 70   | 80   | 90   | MAX  |
| MAX WIND SPEED | 5.3 | 15.1 | 18.8 | 23.3 | 27.5 | 33.8 | 39.5 | 45.3 | 50.7 | 59.2 | 81.7 |
| 100m SHEAR POS | 1.7 | 2.6  | 3.0  | 3.3  | 3.6  | 3.9  | 4.1  | 4.5  | 4.9  | 5.6  | 14.2 |
| NEG            | 1.6 | 2.5  | 2.8  | 3.1  | 3.4  | 3.7  | 4.0  | 4.4  | 3.9  | 5.7  | 19.1 |
| 1 km SHEAR POS | 3.7 | 7.8  | 9.1  | 10.2 | 11.5 | 12.3 | 13.5 | 15.0 | 17.0 | 19.5 | 48.0 |
| NEG            | 2.3 | 6.0  | 7.1  | 8.0  | 8.9  | 9.9  | 11.0 | 12.3 | 14.2 | 17.4 | 33.5 |
| 400m SHEAR POS | 2.8 | 5.6  | 6.5  | 7.2  | 7.8  | 8.4  | 9.3  | 10.1 | 11.1 | 12.6 | 24.1 |
| NEG            | 3.1 | 4.8  | 5.5  | 6.4  | 6.9  | 7.7  | 8.5  | 9.5  | 10.7 | 12.7 | 20.0 |
| 3 km SHEAR POS | 2.7 | 10.6 | 12.8 | 15.4 | 17.2 | 19.1 | 21.2 | 23.6 | 26.4 | 30.3 | 97.0 |
| NEG            | 0.0 | 3.3  | 6.1  | 7.5  | 8.7  | 9.9  | 10.9 | 12.6 | 14.7 | 18.4 | 38.3 |

When all nine characteristics are used to typify a profile, 4 pairs of the 900 profiles were identical. Their codings (in codes, the tenth decile is indicated as X) were:

1 11 11 11 13 at 0100Z on 26 Jul 66 and at 1503Z on 9 Aug 66;  
 1 11 12 11 13 at 0432Z on 11 Aug 65 and at 0100Z on 20 Aug 65;  
 3 11 11 11 13 at 0906Z on 16 Sep 66 and at 0100Z on 21 Sep 66;  
 X 7X XX XX XX at 1300Z on 20 Jan 65 and at 0215Z on 24 Feb 66.

These four were among 34 sets of two or more profiles which were coded identically with respect to the five primary characteristics: 1 quintuplet, 3 quadruplets, 3 triplets, and 27 doublets (Table 3.3)



TABLE 3.3

REPEATED CODINGS AMONG 900 JIMSPHERE PROFILES, WITH  
TIME AND DATE OF SOUNDINGS. (IN CODE, X = 10)

|         |       |         |       |         |       |         |       |                      |
|---------|-------|---------|-------|---------|-------|---------|-------|----------------------|
| *111111 | 1300Z | 7Jul65  | 0100Z | 6Aug65  | 0100Z | 26Jul66 | 1503Z | 9Aug66               |
| *111112 | 1300Z | 14Jul65 | 0432Z | 11Aug65 | 0100Z | 20Aug65 | 0100Z | 60ct66               |
| 111113  | 0932Z | 11Aug65 | 1300Z | 20Sep65 |       |         |       |                      |
| 111121  | 1300Z | 9Sep65  | 0159Z | 13Jul65 | 1300Z | 8Jul66  |       |                      |
| 112111  | 0101Z | 18Aug65 | 1533Z | 9Aug66  |       |         |       |                      |
| 112112  | 0102Z | 28Aug65 | 0100Z | 20Sep65 |       |         |       |                      |
| 121111  | 1300Z | 3Aug65  | 1445Z | 11Aug65 |       |         |       |                      |
| 123114  | 1300Z | 16Jul65 | 1400Z | 6Sep66  |       |         |       |                      |
| 211111  | 1901Z | 2Jul65  | 0100Z | 19Aug65 | 0806Z | 16Sep66 |       |                      |
| 211112  | 1847Z | 2Jul65  | 1746Z | 15Sep66 |       |         |       |                      |
| 211124  | 0100Z | 25Jun66 | 0100Z | 1Dec66  |       |         |       |                      |
| 212113  | 0330Z | 25Aug66 | 1004Z | 12Sep66 |       |         |       |                      |
| *311111 | 0906Z | 16Sep66 | 0100Z | 21Sep66 |       |         |       |                      |
| 311121  | 0100Z | 29May65 | 0100Z | 16Aug65 |       |         |       |                      |
| 332114  | 2030Z | 14Sep65 | 0100Z | 10Dec65 |       |         |       |                      |
| 37335   | 2135Z | 18Apr67 | 2240Z | 18Apr67 |       |         |       |                      |
| 45153   | 2300Z | 19Oct65 | 1445Z | 15Mar67 |       |         |       |                      |
| 46448   | 1417Z | 28Sep65 | 0125Z | 24May66 |       |         |       |                      |
| 48472   | 2330Z | 22May65 | 1300Z | 21Apr67 |       |         |       |                      |
| 4XX68   | 0440Z | 30May66 | 0500Z | 4Jul66  |       |         |       |                      |
| 69874   | 1732Z | 17Feb67 | 1732Z | 17Feb67 |       |         |       |                      |
| 7XX77   | 1302Z | 24Mar66 | 2101Z | 3Feb67  |       |         |       |                      |
| 886XX   | 0100Z | 3Mar66  | 1302Z | 1Mar67  |       |         |       |                      |
| 9XX99   | 1228Z | 5Apr66  | 1728Z | 5Apr66  |       |         |       |                      |
| 9XXX    | 0101Z | 20Jan65 | 1300Z | 6Jan66  |       |         |       |                      |
| X6786   | 1607Z | 5Apr66  | 0835Z | 8Apr66  |       |         |       |                      |
| X797X   | 2230Z | 27Jan65 | 1715Z | 25Feb66 |       |         |       |                      |
| *X7XXX  | 1300Z | 20Jan65 | 0215Z | 24Feb66 |       |         |       |                      |
| X8X99   | 1549Z | 28Mar66 | 0100Z | 10Feb67 |       |         |       |                      |
| X8X9X   | 1300Z | 19Jan66 | 1306Z | 29Nov66 |       |         |       |                      |
| X8XXX   | 1213Z | 28Mar66 | 1800Z | 7Apr66  |       |         |       |                      |
| X99XX   | 0715Z | 26Feb66 | 0945Z | 26Feb66 | 1653Z | 28Mar66 | 1134Z | 29Mar66 1300Z 7Apr66 |
| XX9X    | 1001Z | 10Mar65 | 0100Z | 2Feb66  |       |         |       |                      |
| XXXX    | 0100Z | 9Mar65  | 0151Z | 10Mar65 | 1318Z | 27Jan66 |       |                      |

\*Identical for all nine characteristics on two of dates listed.

### 3.5 RELATIONS

Several interesting relations among the 900 profiles were revealed when they were coded by 9-digit numbers, according to the decile of each of 9 characteristics.

The four test characteristics, maximum 400-meter and 3 km positive and negative shears, had been originally selected because of presumed independence from the selection characteristics, maximum wind speed and maximum 100-meter and 1 km positive and negative shears. However, three of the four test characteristics were found to be strongly related to the selection characteristics. The fourth, the maximum 3 km negative shear, had very little relation to any of the other eight characteristics.

These relations were found from bivariate listings of all the 900 profiles by the deciles in which they fell according to pairs of characteristics. The 36 possible two-way comparison tables are given in Appendix II. For quick computation, each table was partitioned into four quarters, and the number of entries in one quarter was counted. Because each line and each column in a table represents a decile, it contains 90 entries, and the sum of two quarters, horizontally or vertically, is 450. Thus the total in each quarter differs from  $900/4 = 225$  by the same amount, and only one quarter need be counted. These differences are given in the upper right part of Table 3.4.

The net difference between any quarter's total and 225 is an index of the correlation between the two characteristics of the table. Divided by 225, this number is analogous to a coefficient of medial correlation, because the division into quarters effectively classified the characteristics by their medians. The coefficient of medial correlation,  $q$ , from a sample of  $n$  independent pairs, has a sampling variance of approximately  $(1 - q^2) / n$ , so that for  $n = 900$  any value of  $q$  greater than 0.06 differs from zero at the 95% confidence level.

TABLE 3.4

## MEDIAL COMPARISONS BETWEEN PAIRS OF CHARACTERISTICS

| MAXIMUM:       |     | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|----------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| WIND SPEED     | (1) | -   | 73  | 93  | 107 | 77  | 85  | 73  | 143 | 22  |
| 100m SHEAR POS | (2) | .35 | -   | 89  | 88  | 53  | 114 | 66  | 73  | 29  |
| 100m SHEAR NEG | (3) | .41 | .40 | -   | 80  | 102 | 89  | 134 | 80  | 37  |
| 1 km SHEAR POS | (4) | .48 | .39 | .36 | -   | 83  | 134 | 60  | 136 | 37  |
| 1 km SHEAR NEG | (5) | .34 | .24 | .45 | .37 | -   | 74  | 124 | 68  | 66  |
| 400m SHEAR POS | (6) | .38 | .51 | .40 | .60 | .33 | -   | 38  | 97  | 41  |
| 400m SHEAR NEG | (7) | .32 | .29 | .60 | .36 | .55 | .39 | -   | 79  | 53  |
| 3 km SHEAR POS | (8) | .64 | .32 | .36 | .60 | .39 | .43 | .35 | -   | 52  |
| 3 km SHEAR NEG | (9) | .10 | .13 | .16 | .16 | .29 | .18 | .24 | .23 | -   |

Values of the medial correlation are given in the lower left of Table 3.4. All correlations are positive and significantly greater than 0. Lines separate the first five selection characteristics from the last four test characteristics. The largest correlations appear between the two groups, especially between the positive 100m and 400m maximum shears, the 100m and 400m negative shears, and maximum wind speed and positive 3 km shear. The highest correlation within the selection group is .48, within the test group .43, but 6 of the 20 inter-group correlations are larger than .50. Least correlation is shown by the 3 km negative shear, for which the maximum correlation, .29, is with 1 km negative shear.

### 3.6 SAMPLING

The 900 profiles were sampled, to fill up the matrix of five characteristics vs. deciles (Table 3.1), in three different ways: in direct chronological order, in reverse chronological order, and after complete randomization; in the following discussion, these are termed Direct, Reverse, and Random. Five different randomizations were used, so that 7 samples were drawn. These sampling orders were used repeatedly, for lower and upper limits of 1, 2, 3, 4, and 5 entries per cell.

The number,  $n$ , of profiles in samples with at most  $m$  entries per cell, and in samples with at least  $m$  entries per cell, for  $m = 1, 2, 3, 4, 5$ , is given in Table 3.5, together with the ordinal ( $N$ ) of the last profile used in the sample. These two numbers are presented as a fraction,  $n/N$ , which suggests the efficiency of the sampling procedure. For example, when the 900 profiles were examined in Direct (chronological) order to obtain at least  $m = 2$  entries per cell, a total of 44 profiles were accepted. The 44th was the 151st profile examined, after which the examination stopped without considering the remaining 749 profiles. But when the same Direct sequence was examined to obtain at most  $m = 2$  entries per cell, only 17 profiles were accepted, the 17th being the 571st examined. But since some cells still did not have 2 entries, the remaining 329 profiles were all examined, to no avail.

In general, seeking at least  $m$  entries per cell involved examining  $N = 2m$  to  $3m$  or more profiles in Direct or Inverse order but less than  $2m$  Random order profiles to meet the criterion. At most  $m$  entries, however, was never attained, even though all 900 profiles were examined. The values of  $n$  in Table 3.5 are shown in Figure 3.2, for all five random sampling arrangements. In Figure 3.2, the diagonal line represents the optimum number, if each cell had exactly  $m$  entries.

When an upper limit is placed on cell content, the actual number of profiles in the sample is about 90% of optimum, for each sampling sequence. But when a lower limit is imposed, many more profiles are used in the Direct and Reverse procedures than for Random. This effect is also seen in the actual matrices developed for each process: both Direct and Reverse ordering resulting in many cells having larger excesses above the minimum than for any of the 5 Random samples. Hence, further discussion will concentrate on the results of the Random sampling.

The actual numbers of entries per cell for each of the selection characteristics ( $c_1, c_2, c_3, c_4, c_5$ ), and also the number of entries for the four test characteristics ( $c_6, c_7, c_8, c_9$ ), are given in Appendix III for each of five Random sampling sequences, used to select at least and at most  $m$  entries per cell.

### 3.7 VALIDATION

To summarize the figures in the fifty  $9 \times 10$  matrices in Appendix III, the deciles have been grouped into three classes, low (1-3), middle (4-7), and high (8-10). For each class, all the entries for the five selection characteristics were totaled, and similarly for the four test characteristics. Ideally, the low and high classes should each have 30 percent of the entries, and the middle class 40 percent.

The actual proportions, computed to tenths of a percent and expressed as

TABLE 3.5

NUMBER OF PROFILES USED (n) AND ORDINAL (N) OF LAST PROFILE USED,  
 IN COMPLETING DECILE MATRIX WITH AT LEAST m PROFILES PER  
 CELL AND IN ATTEMPTING TO COMPLETE WITH AT MOST m PROFILES  
 PER CELL, FROM 2 ORDERED AND 5 RANDOM SEQUENCES OF 900 WIND PROFILES.

|                   | m: 1  | 2      | 3      | 4      | 5      |
|-------------------|-------|--------|--------|--------|--------|
| <u>At least m</u> |       |        |        |        |        |
| Direct            | -     | 44/151 | 62/152 | 81/158 | 87/160 |
| Inverse           | -     | 44/158 | 62/220 | 80/222 | 96/229 |
| Random 1          | 23/32 | 37/73  | 52/86  | 64/100 | 74/103 |
| Random 2          | 21/39 | 40/53  | 51/100 | 63/103 | 75/109 |
| Random 3          | 21/57 | 36/62  | 50/73  | 59/95  | 72/102 |
| Random 4          | 19/63 | 35/78  | 50/79  | 64/86  | 75/103 |
| Random 5          | 21/26 | 33/40  | 48/57  | 61/89  | 75/94  |
| <u>At most m</u>  |       |        |        |        |        |
| Direct            | -     | 17/571 | 26/571 | 35/639 | 46/247 |
| Inverse           | -     | 17/856 | 24/883 | 34/280 | 44/599 |
| Random 1          | 8/531 | 17/397 | 26/567 | 34/448 | 46/374 |
| Random 2          | 8/493 | 17/256 | 27/767 | 38/589 | 46/831 |
| Random 3          | 8/842 | 19/807 | 26/292 | 35/842 | 44/886 |
| Random 4          | 8/520 | 16/743 | 26/561 | 35/776 | 45/776 |
| Random 5          | 8/373 | 16/821 | 27/847 | 36/847 | 45/720 |

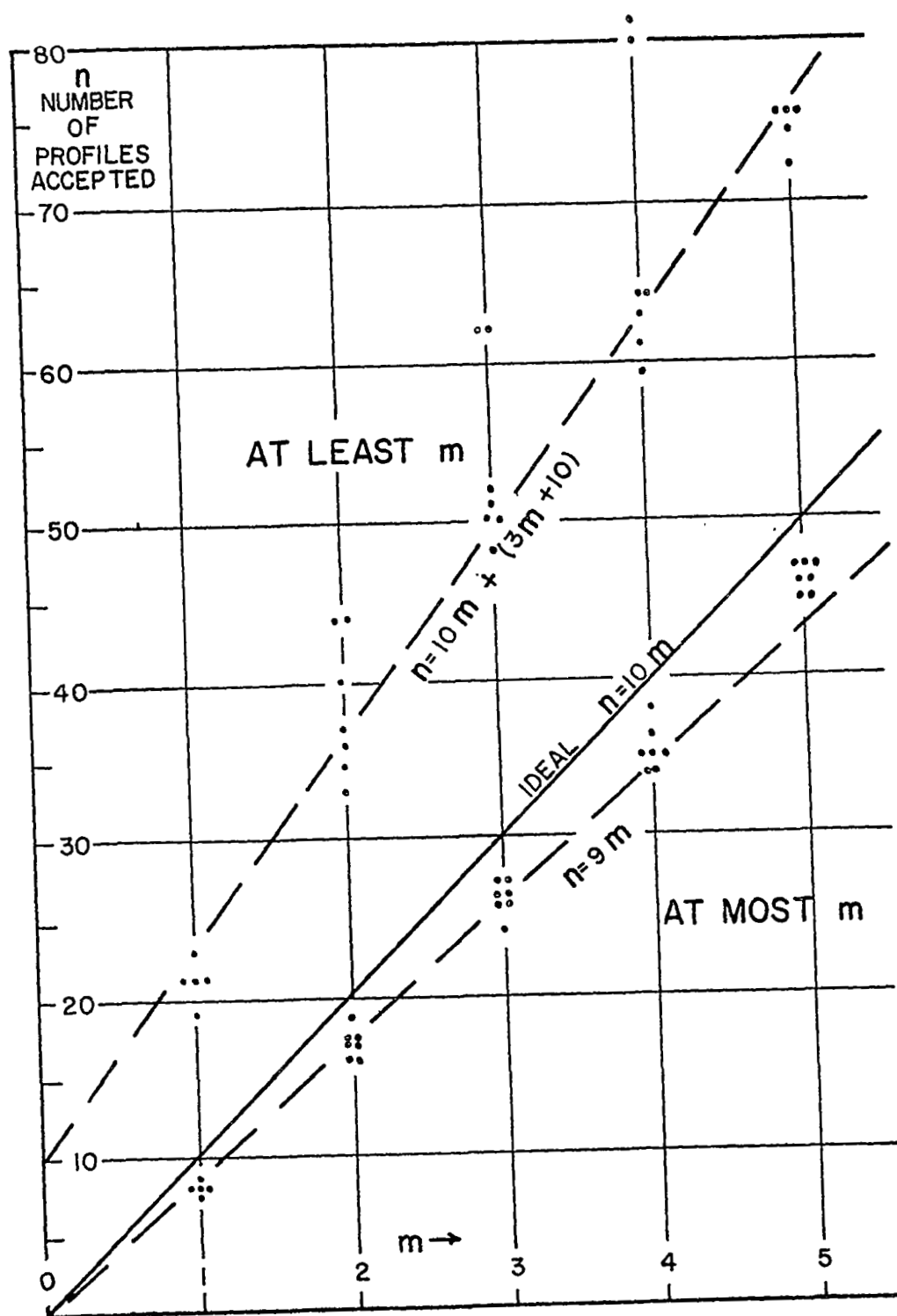


Figure 3.2 Number of Profiles Accepted ( $n$ ) in Seeking at Least or at Most  $m$  Entries per Cell for Five Random Sampling Arrangements; Diagonal Line represents the Optimum Number, if Each Cell has Exactly  $m$  Entries.

parts per thousand for convenience (eliminating the decimal point), are given in Table 3.6 for each of the 5 Random sequence selections. These numbers, in turn, are shown by bars in Figure 3.3.

In each of the 50 samples, the number of entries in the three groups was gratifyingly close to the ideal figures. Since the upper extremes of wind speed and wind shear are of greatest practical interest, only the high group need be examined here. The actual percentages obtained in the sampling procedure varied from 26.7 (Random sequence 2 for at least 4) to 37.5 (Random sequence 4 for at most 1), for the selection characteristics, and from 19.0 (Random sequence 5 for at least 1) to 50.0 (Random sequence 1 for at most 1).

Together, the 5 Random sequences slightly overemphasized the high deciles for the selection characteristics, giving them from 29.9 (at most 5) to 34.5 (at least 1) percent of the cell entries. But for the test characteristics the high deciles were underemphasized: 26.1 for at least 1, 31.8 for at most 1. In the grand average, for all sequences for all values of  $m$ , the high deciles obtained 31.3 of all entries for selection characteristics, 28.9 for test characteristics.

As another test of how well the decile coding and sorting provided samples representative of the entire population of 900 profiles, spectrum densities for each of the profiles in one sample were extracted. Chosen were the five groups of profiles obtained in seeking at most 3 entries per decile cell. As shown in Table 3.5 and Figure 3.2, three of these groups had 26 profiles each and two had 27 each. For ease in comparison, however, each group was reduced to 25 profiles, by eliminating the 26th and 27th to be selected.

Serial numbers of the 25 profiles making up each stratified sample are given in Table 3.7. Although only 900 profiles were available for sampling, the serial numbers run from 1 to 1186, because 286 profiles in the original tabulation were rejected for not being complete from 1 to 14 km, or being duplicates of other profiles. In each of the five stratified samples, the pro-



TABLE 3.6

RELATIVE NUMBERS (PER THOUSAND) OF ENTRIES IN 3 GROUPS OF DECILES (LOW, MIDDLE, HIGH) FOR ALL 5 SELECTION CHARACTERISTICS (LEFT NUMBERS) AND ALL 4 TEST CHARACTERISTICS (RIGHT NUMBERS) WHEN 5 RANDOM SEQUENCES ARE USED TO SELECT PROFILES TO FILL MATRICES WITH AT LEAST  $m$  AND AT MOST  $m$  ENTRIES PER CELL.

|                 |                | AT LEAST $m$ |         |         |                | AT MOST $m$ |         |         |  |
|-----------------|----------------|--------------|---------|---------|----------------|-------------|---------|---------|--|
| Random Sequence |                | 1-3          | 4-7     | 8-10    | Deciles        | 1-3         | 4-7     | 8-10    |  |
|                 | $\overline{m}$ |              |         |         | $\overline{m}$ |             |         |         |  |
| 1               | 1              | 235/228      | 426/424 | 339/348 | 1              | 300/281     | 350/219 | 350/500 |  |
|                 | 2              | 303/311      | 373/385 | 324/304 | 2              | 282/309     | 400/338 | 318/353 |  |
|                 | 3              | 312/303      | 377/394 | 312/303 | 3              | 282/308     | 385/317 | 323/375 |  |
|                 | 4              | 309/281      | 369/414 | 322/315 | 4              | 300/294     | 388/360 | 312/346 |  |
|                 | 5              | 308/277      | 359/405 | 332/318 | 5              | 291/255     | 400/424 | 309/321 |  |
|                 | Avg            | 293/280      | 381/404 | 326/316 | Avg            | 291/289     | 385/332 | 322/379 |  |
| 2               | 1              | 343/274      | 333/440 | 324/286 | 1              | 225/125     | 425/500 | 350/375 |  |
|                 | 2              | 320/244      | 400/513 | 280/244 | 2              | 294/250     | 388/441 | 318/309 |  |
|                 | 3              | 310/260      | 419/500 | 271/240 | 3              | 289/250     | 400/440 | 311/306 |  |
|                 | 4              | 324/282      | 410/480 | 267/238 | 4              | 289/243     | 400/454 | 311/303 |  |
|                 | 5              | 304/273      | 408/460 | 288/267 | 5              | 313/293     | 396/440 | 291/266 |  |
|                 | Avg            | 320/267      | 394/479 | 286/255 | Avg            | 282/232     | 402/455 | 316/312 |  |
| 3               | 1              | 222/286      | 472/429 | 306/286 | 1              | 300/281     | 350/438 | 350/281 |  |
|                 | 2              | 250/285      | 433/424 | 317/292 | 2              | 305/289     | 389/408 | 305/303 |  |
|                 | 3              | 268/300      | 428/405 | 304/295 | 3              | 300/317     | 400/375 | 300/308 |  |
|                 | 4              | 275/305      | 420/381 | 305/314 | 4              | 280/329     | 446/386 | 274/286 |  |
|                 | 5              | 297/299      | 417/399 | 286/302 | 5              | 286/341     | 418/375 | 295/284 |  |
|                 | Avg            | 262/295      | 434/408 | 304/298 | Avg            | 294/311     | 401/396 | 305/292 |  |
| 4               | 1              | 295/289      | 400/513 | 305/197 | 1              | 325/250     | 300/531 | 375/219 |  |
|                 | 2              | 274/271      | 394/471 | 331/257 | 2              | 288/266     | 375/453 | 338/281 |  |
|                 | 3              | 272/275      | 392/480 | 336/245 | 3              | 300/269     | 408/471 | 292/260 |  |
|                 | 4              | 266/270      | 409/475 | 325/255 | 4              | 297/279     | 383/443 | 320/279 |  |
|                 | 5              | 293/297      | 403/460 | 304/243 | 5              | 307/295     | 382/454 | 311/251 |  |
|                 | Avg            | 280/280      | 400/480 | 320/239 | Avg            | 303/272     | 370/470 | 327/258 |  |
| 5               | 1              | 343/357      | 381/452 | 276/190 | 1              | 275/313     | 425/469 | 300/219 |  |
|                 | 2              | 273/288      | 376/402 | 352/311 | 2              | 275/297     | 400/469 | 325/234 |  |
|                 | 3              | 313/318      | 350/375 | 338/307 | 3              | 304/306     | 393/417 | 304/278 |  |
|                 | 4              | 331/290      | 361/423 | 308/286 | 4              | 317/299     | 378/417 | 306/285 |  |
|                 | 5              | 331/300      | 357/403 | 312/297 | 5              | 307/294     | 404/411 | 289/294 |  |
|                 | Avg            | 318/311      | 365/411 | 317/278 | Avg            | 276/302     | 400/437 | 305/262 |  |
| Grand Avg       | Avg            | 295/298      | 395/436 | 311/277 | Gr. Avg        | 294/281     | 391/418 | 315/301 |  |
|                 | 1              | 287/287      | 402/451 | 310/261 | 1              | 285/250     | 370/431 | 345/318 |  |
|                 | 2              | 284/280      | 395/439 | 321/282 | 2              | 289/282     | 390/422 | 321/296 |  |
|                 | 3              | 295/291      | 393/431 | 312/278 | 3              | 295/290     | 397/404 | 306/305 |  |
|                 | 4              | 301/286      | 394/435 | 305/279 | 4              | 297/289     | 403/412 | 300/299 |  |
|                 | 5              | 307/289      | 389/425 | 304/286 | 5              | 301/296     | 400/421 | 299/283 |  |

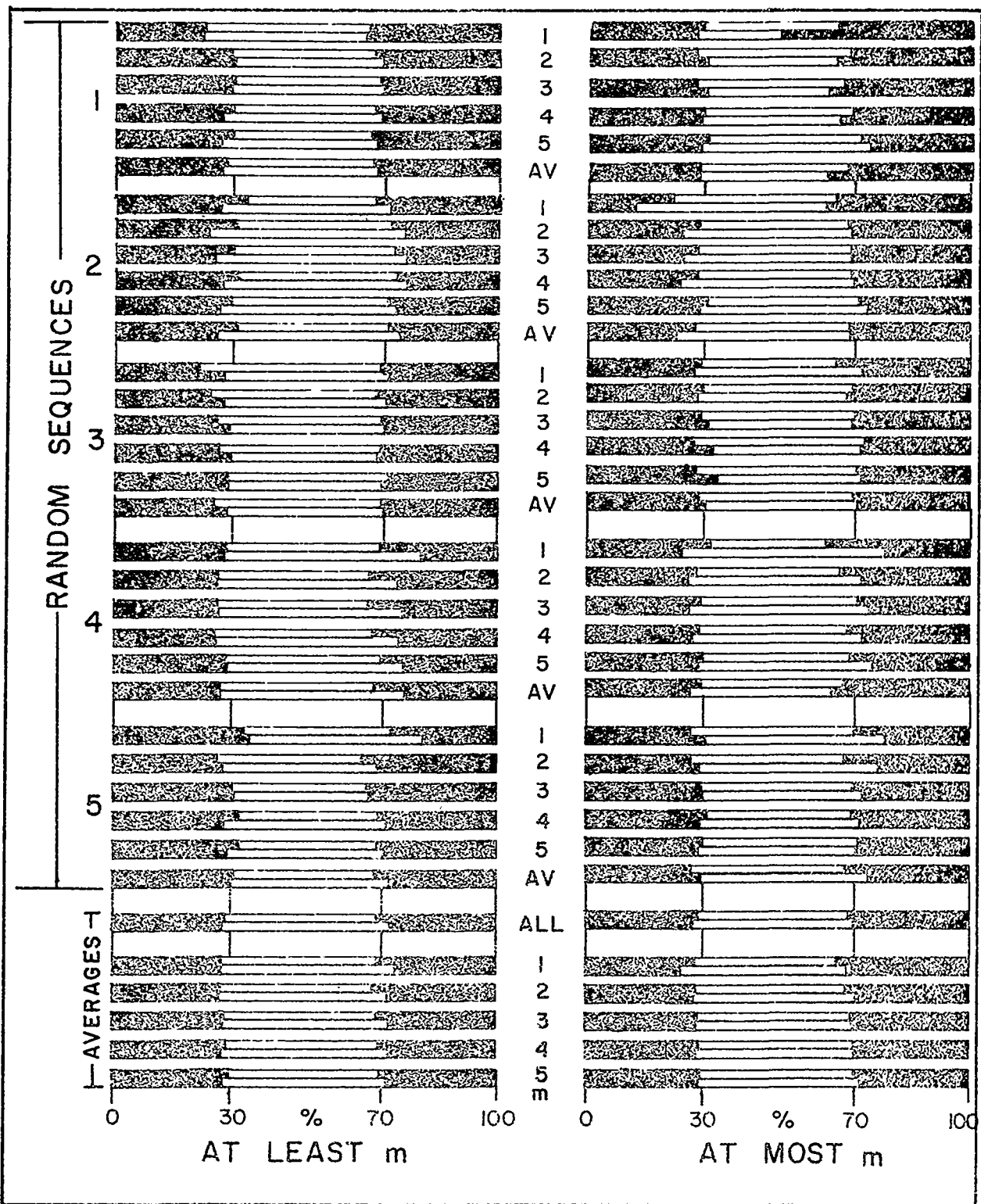


Figure 3.3 Percent of Entries in Low (1-3), Middle (4-7), and High (8-10) Deciles of Wind Characteristics in Samples Obtained from Random Sequences of Wind Profiles.

TABLE 3.7

COMPOSITION OF 5 STRATIFIED RANDOM SAMPLES OF  
WIND PROFILES FROM TOTAL SAMPLE OF 900 PROFILES  
OVER CAPE KENNEDY, FLORIDA. NUMBERS ARE IDENTIFICATION  
NUMBERS OF PROFILES IN BASIC SAMPLE.

| <u>RS 1</u> | <u>RS 2</u> | <u>RS 3</u> | <u>RS 4</u> | <u>RS 5</u> |
|-------------|-------------|-------------|-------------|-------------|
| 1092        | 731         | 511         | 1042        | 696         |
| 251         | 323         | 1157        | 595         | 66          |
| 997         | 723         | 860         | 679         | 380         |
| 864         | 820         | 1034        | 1144        | 595         |
| 67          | 533         | 340         | 913         | 1041        |
| 197         | 168         | 344         | 1191        | 413         |
| 562         | 292         | 917         | 107         | 763         |
| 665         | 630         | 1063        | 674         | 492         |
| 88          | 827         | 715         | 649         | 426         |
| 802         | 487         | 358         | 1009        | 933         |
| 634         | 688         | 973         | 533         | 1175        |
| 637         | 1109        | 878         | 763         | 780         |
| 457         | 319         | 608         | 113         | 388         |
| 1008        | 995         | 4           | 370         | 718         |
| 878         | 677         | 54          | 13          | 44          |
| 623         | 348         | 160         | 1031        | 1135        |
| 1089        | 643         | 392         | 895         | 207         |
| 455         | 992         | 240         | 271         | 469         |
| 852         | 735         | 411         | 902         | 324         |
| 325         | 1173        | 822         | 653         | 208         |
| 340         | 85          | 432         | 844         | 56          |
| 314         | 1027        | 695         | 492         | 708         |
| 363         | 299         | 942         | 266         | 200         |
| 963         | 711         | 1113        | 707         | 459         |
| 713         | 791         | 545         | 180         | 470         |

files appear to have been drawn from the entire number with no bias.

For each group of 25 profiles, six spectrum densities at 10 frequencies are given in Table 3.8, and graphed in Figure 3.4. Values are in  $(\text{m/sec})^2/(\text{cyc/sec})$ . At each frequency from 0.3 to 3.0 cycles/second, the densities shown are the minimum, 5th, 10th, 15th, and 20th smallest, and the largest. For comparison, the corresponding percentile values of the densities in the entire population are also shown.

In Figure 3.4, the lines connect the densities for the entire 900 profile sample, and the vertical bars indicate the range of the values for the 5 stratified Random samples. At each frequency, the maximum and minimum densities of the 5 samples do not attain the whole-sample values, but at the four intervening percentiles the range of the 5 sample values includes the whole-sample density.

On the whole, the spectrum of any one of the 5 stratified Random samples appears to offer a fair approximation to that of the whole sample. This investigation of 5 stratified samples, chosen arbitrarily from those available from the decile coding procedure, suggests that the method does indeed provide suitable samples of wind profiles.

Whether a stratified sample should be drawn by the "at most  $m$ " or "at least  $m$ " criterion depends on several factors. The former provides smaller samples, and is the only one available for samples of 25 or less, as long as decile coding is used. However, the selection characteristics could be coded in fewer ( $q$ ) categories, such as quartiles ( $q = 4$ ) or quintiles ( $q = 5$ ). If quartiles are used, presumably samples of only 6 or 7 would be provided by a criterion of "at most 2" and of 12 to 15 by "at least 2".

The "at least  $m$ " criterion is more efficient, in that the selection process stops as soon as the minimum is reached in all cells, while the "at most  $m$ " criterion requires scanning of the entire set of available profiles in an

TABLE 3.8

SPECTRUM DENSITIES AT 10 FREQUENCIES OF 5 STRATIFIED RANDOM SAMPLES OF 25 WIND PROFILES EACH, AND OF ENTIRE SAMPLE OF 900 PROFILES OVER CAPE KENNEDY. GIVEN, IN  $(\text{m/sec})^2/(\text{cyc/sec})$ , ARE MINIMUM AND MAXIMUM VALUES AND 5TH, 10TH, 15TH, AND 20TH ORDERED VALUES IN EACH RANDOM SAMPLE AT EACH FREQUENCY, AND CORRESPONDING PERCENTILE VALUES OF TOTAL SAMPLE.

|             | CYCLES PER SECOND |       |       |       |       |       |       |       |       |       |
|-------------|-------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| <u>MAX</u>  | 0.3               | 0.6   | 0.9   | 1.2   | 1.5   | 1.8   | 2.1   | 2.4   | 2.7   | 3.0   |
| RS 1        | 4.553             | 1.052 | .2881 | .1467 | .0859 | .0699 | .0594 | .0688 | .0837 | .0879 |
| RS 2        | 4.923             | 0.985 | .3205 | .1467 | .1577 | .1504 | .1296 | .1274 | .1284 | .1233 |
| RS 3        | 7.748             | 1.549 | .3810 | .1537 | .1096 | .0904 | .0709 | .0680 | .0681 | .0907 |
| RS 4        | 5.275             | 1.209 | .3300 | .0528 | .0902 | .0746 | .0718 | .0769 | .0725 | .0667 |
| RS 5        | 5.246             | 1.005 | .2566 | .1240 | .0961 | .0732 | .0622 | .0642 | .0413 | .0263 |
| TOT         | 7.916             | 1.727 | .6652 | .3916 | .1941 | .1583 | .1453 | .1621 | .1703 | .1555 |
| <u>80 %</u> |                   |       |       |       |       |       |       |       |       |       |
| RS 1        | 3.402             | 0.828 | .2397 | .0884 | .0570 | .0421 | .0331 | .0244 | .0174 | .0149 |
| RS 2        | 3.052             | 0.702 | .2240 | .0861 | .0485 | .0363 | .0232 | .0223 | .0208 | .0190 |
| RS 3        | 2.756             | 0.745 | .2439 | .0163 | .0566 | .0430 | .0319 | .0263 | .0200 | .0183 |
| RS 4        | 2.789             | 0.742 | .2072 | .0820 | .0601 | .0384 | .0270 | .0294 | .0215 | .0219 |
| RS 5        | 3.086             | 0.680 | .2181 | .0841 | .0501 | .0355 | .0274 | .0195 | .0138 | .0133 |
| TOT         | 2.955             | 0.736 | .2315 | .0983 | .0553 | .0363 | .0271 | .0211 | .0178 | .0166 |
| <u>60 %</u> |                   |       |       |       |       |       |       |       |       |       |
| RS 1        | 2.027             | 0.722 | .1660 | .0700 | .0400 | .0281 | .0218 | .0149 | .0121 | .0121 |
| RS 2        | 2.060             | 0.540 | .1663 | .0692 | .0398 | .0266 | .0201 | .0179 | .0130 | .0114 |
| RS 3        | 2.353             | 0.567 | .1980 | .0786 | .0451 | .0304 | .0211 | .0149 | .0101 | .0098 |
| RS 4        | 2.567             | 0.552 | .1655 | .0682 | .0430 | .0275 | .0193 | .0133 | .0136 | .0142 |
| RS 5        | 2.037             | 0.523 | .1430 | .0652 | .0387 | .0250 | .0179 | .0128 | .0097 | .0096 |
| TOT         | 2.189             | 0.569 | .1809 | .0762 | .0419 | .0267 | .0188 | .0142 | .0116 | .0109 |
| <u>40 %</u> |                   |       |       |       |       |       |       |       |       |       |
| RS 1        | 1.632             | 0.449 | .1455 | .0617 | .0368 | .0216 | .0137 | .0101 | .0089 | .0087 |
| RS 2        | 1.558             | 0.413 | .1249 | .0575 | .0300 | .0194 | .0133 | .0124 | .0092 | .0082 |
| RS 3        | 1.479             | 0.496 | .1319 | .0528 | .0344 | .0256 | .0168 | .0100 | .0076 | .0066 |
| RS 4        | 1.741             | 0.450 | .1276 | .0584 | .0317 | .0219 | .0148 | .0101 | .0098 | .0109 |
| RS 5        | 1.623             | 0.386 | .1092 | .0568 | .0315 | .0219 | .0131 | .0097 | .0082 | .0066 |
| TOT         | 1.719             | 0.450 | .1455 | .0634 | .0343 | .0208 | .0140 | .0103 | .0086 | .0079 |
| <u>20 %</u> |                   |       |       |       |       |       |       |       |       |       |
| RS 1        | 1.476             | 0.335 | .1248 | .0476 | .0257 | .0158 | .0104 | .0070 | .0060 | .0060 |
| RS 2        | 1.097             | 0.275 | .1068 | .0439 | .0197 | .0113 | .0086 | .0072 | .0065 | .0046 |
| RS 3        | 1.301             | 0.293 | .0958 | .0476 | .0314 | .0162 | .0083 | .0062 | .0054 | .0046 |
| RS 4        | 1.455             | 0.421 | .1100 | .0533 | .0300 | .0162 | .0097 | .0083 | .0080 | .0073 |
| RS 5        | 1.084             | 0.317 | .1020 | .0444 | .0274 | .0175 | .0119 | .0080 | .0070 | .0052 |
| TOT         | 1.177             | 0.336 | .1123 | .0489 | .0263 | .0161 | .0103 | .0075 | .0062 | .0054 |
| <u>MIN</u>  |                   |       |       |       |       |       |       |       |       |       |
| RS 1        | 0.382             | 0.142 | .0756 | .0399 | .0182 | .0110 | .0068 | .0053 | .0041 | .0040 |
| RS 2        | 0.776             | 0.263 | .0661 | .0232 | .0133 | .0092 | .0066 | .0036 | .0026 | .0018 |
| RS 3        | 0.858             | 0.197 | .0490 | .0225 | .0130 | .0079 | .0055 | .0034 | .0024 | .0020 |
| RS 4        | 0.932             | 0.281 | .0848 | .0329 | .0145 | .0077 | .0066 | .0041 | .0026 | .0026 |
| RS 5        | 0.374             | 0.147 | .0600 | .0223 | .0115 | .0071 | .0045 | .0050 | .0040 | .0027 |
| TOT         | 0.373             | 0.136 | .0490 | .0202 | .0107 | .0063 | .0037 | .0021 | .0014 | .0013 |

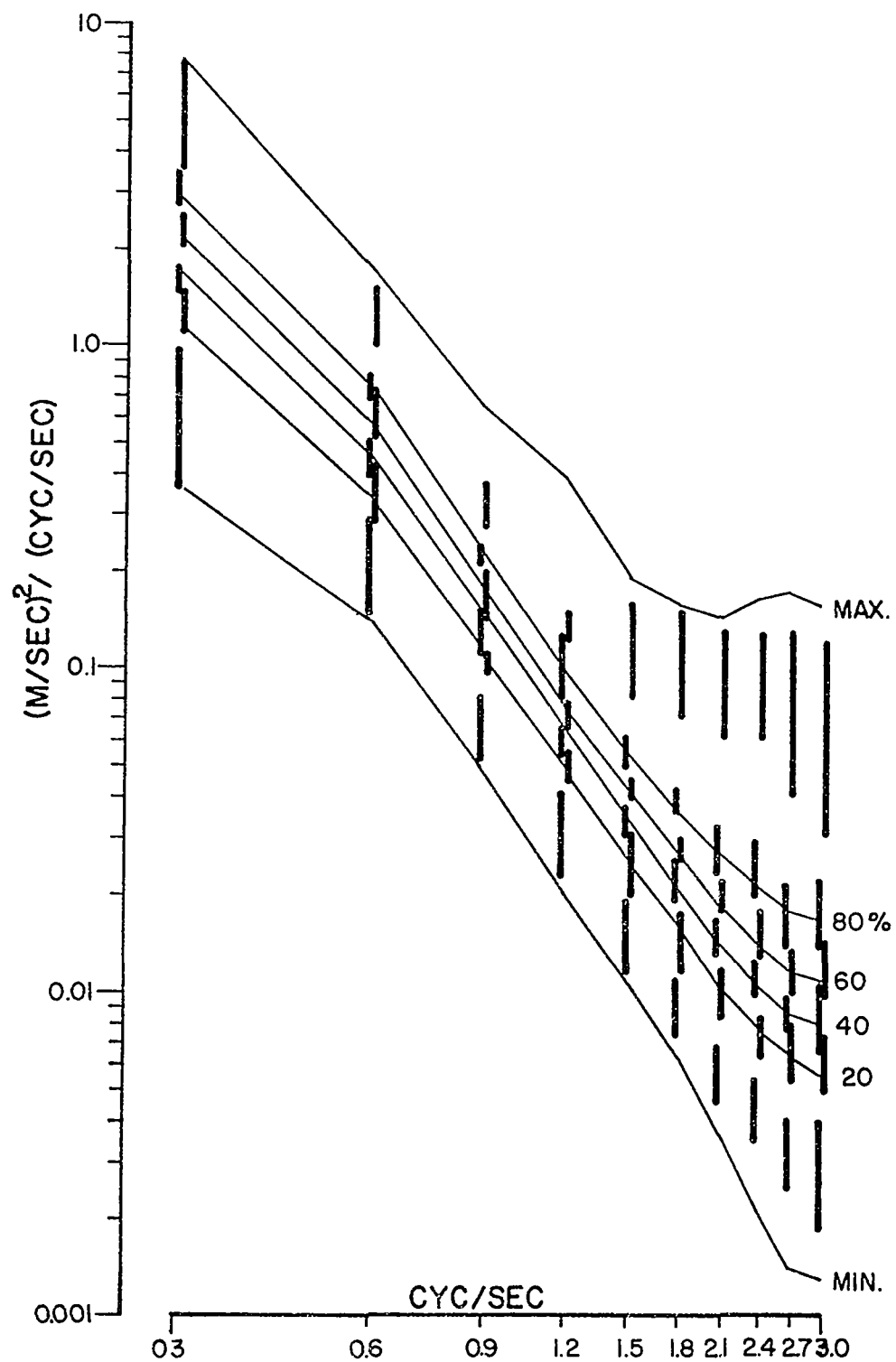


Figure 3.4 Range of Spectrum Densities at 10 Frequencies of 5 Stratified Random Samples, and Densities of Entire Sample of 900 Jimsphere Profiles.

effort to obtain a perfect sample of size  $m q$ . Decisions on which to use can be made realistically only after actual trials of the method.

## Section 4

### RELATIONS BETWEEN WIND SHEARS OVER VARIOUS ALTITUDE INTERVALS

#### 4.1 INTRODUCTION

Various analyses of the magnitude of vector wind shears derived from balloon soundings have indicated that the mean and standard deviation of vector shear are functions of layer thickness of the form

$$\bar{w} = C \Delta Z^{n_1} \quad (1)$$

$$\sigma_w = E \Delta Z^{n_2} + D \quad (2)$$

where  $\bar{w}$  and  $\sigma_w$  are the mean and standard deviation (m/sec) of vector shear and  $\Delta Z$  is the layer thickness (m). Adelfang, Ashburn and Court (Ref. 1) showed that Equations 1 and 2 were generally valid for the climatological means and standard deviations computed at particular altitudes for 1194 Cape Kennedy Jimsphere profiles; based on computations at 8, 12, and 16 km for  $\Delta Z$  from 50 to 5,000 m they found that the constants  $n_1$  and  $n_2$  are equal to  $2/3$ ,  $C$  and  $E$  are a function of altitude, and  $D = 0$ . Armendariz and Rider (Ref. 10) also established the validity of Equations 1 and 2 for shear layer thicknesses between 61 and 914 m; their results, which were based upon a series of measurements during August and September 1964, were obtained by detailed tracking of 100 gm. spherical smooth balloons to an altitude of 3.05 km; they found that  $n_2 = 0.74 n_1$ ,  $E = 1.1C^{0.74}$ , and  $D = 0$ . Essenwanger (Ref. 11), who first proposed the form of Equations 1 and 2 based on an analysis of detailed wind measurements from rockets, finds that  $n_1 = n_2$ ; Essenwanger and Reiter (Ref. 12) deduce from consideration of Tatarski's turbulence structure function (Ref. 13) that the constant  $n_1$  (or  $n_2$  since  $n_1 = n_2$ ) has a lower bound of zero for an idealized wind profile composed of wind fluctuations with a "white noise" spectrum and an upper bound of unity for wind profiles composed of a linear trend without turbulence or mesostructure.



In the following discussion two sets of Jimsphere profiles are used to study the relation between mean and standard deviation of vector shear and layer thickness.

#### 4.2 DATA

The two sets of Jimsphere profiles used for this study are composed of 1167 profiles measured over Cape Kennedy [ ETR (Eastern Test Range) ] during the period December 1964 through April 1967 and 83 profiles measured over Point Mugu (PMR) during the period January 1965 through March 1966. Monthly and tri-monthly distributions of the number of soundings for the two sets of data are given in Table 4.1. For an unbiased annual distribution 8.33 and 25 percent of the soundings should occur in any monthly or tri-monthly period respectively; as shown in Table 4.1 both data sets, have a relatively large percentage of the total soundings in the winter strong wind months (1-3), and a relatively small percentage in the fall months (10-12); the principal difference in the two distributions occurs in the spring months (4-6) for which the Point Mugu sample has only 8.43 percent of the soundings compared to 28.91 percent for Cape Kennedy.

Vector shears were computed for all the soundings of the two data sets at 1 km intervals from 8 to 15 km for  $\Delta Z$  equal to 50, 100, 400, 800, 1,000, 3,000, and 5,000 m. The vector shear at altitude  $Z$  is defined as the magnitude of the difference between two horizontal wind vectors, one at altitude  $Z$  and the other at  $Z - \Delta Z$ .

#### 4.3 DISCUSSION

The means ( $\bar{w}$ ) and standard deviations ( $\sigma_w$ ) of vector shears of various layer thicknesses were computed for shear data given at intervals of 1 km between 8 and 15 km; the total number of observations of vector shear for each layer thickness was 8,708 for the Cape Kennedy data and 627 for the Point Mugu data. The means and standard deviations were also computed as a function of altitude

TABLE 4.1

## MONTHLY AND TRI-MONTHLY DISTRIBUTIONS OF CAPE KENNEDY AND POINT MUGU JIMSPHERE PROFILES

| M O N T H L Y   |       |       |       |       |      |      |       |      |      |      |      |       | Total |
|-----------------|-------|-------|-------|-------|------|------|-------|------|------|------|------|-------|-------|
| Month           | 1     | 2     | 3     | 4     | 5    | 6    | 7     | 8    | 9    | 10   | 11   | 12    |       |
| Cape Kennedy    |       |       |       |       |      |      |       |      |      |      |      |       |       |
| No. of Profiles | 92    | 129   | 138   | 169   | 96   | 77   | 83    | 83   | 89   | 81   | 59   | 87    |       |
| % Total         | 7.78  | 10.90 | 11.67 | 14.29 | 8.10 | 6.51 | 7.02  | 7.02 | 7.52 | 6.85 | 4.99 | 7.35  | 1183  |
| Point Mugu      |       |       |       |       |      |      |       |      |      |      |      |       |       |
| No. of Profiles | 8     | 13    | 22    | 2     | 0    | 5    | 11    | 7    | 5    | 0    | 0    | 9     | 83    |
| % Total         | 10.84 | 15.67 | 26.51 | 2.41  | 0    | 6.02 | 13.26 | 8.43 | 6.02 | 0    | 0    | 10.84 |       |

## T R I - M O N T H L Y

|              |            |            |            |             |
|--------------|------------|------------|------------|-------------|
|              | <u>1-3</u> | <u>4-6</u> | <u>7-9</u> | <u>8-12</u> |
| Cape Kennedy | 359        | 342        | 255        | 227         |
| % Total      | 30.34      | 28.91      | 21.56      | 19.19       |
| Point Mugu   | 44         | 7          | 23         | 9           |
| % Total      | 53.01      | 8.44       | 27.71      | 10.84       |

at intervals of 1 km between 8 and 15 km.  $\bar{w}$ ,  $\sigma_w$  and the constants C, E,  $n_1$ , and  $n_2$  of Equations 4.1 and 4.2, calculated by taking logarithmic least squares, are listed in Table 4.2 for Cape Kennedy and Table 4.3 for Point Mugu. In Figure 4.1  $\bar{w}$  computed for the 8 to 15 km altitude band for various layer thicknesses is compared with the Armendariz-Rider and Essenwanger results obtained from late summer profiles (Ref.10); it is indicated that the mean vector shears computed for relatively large samples of wind profiles from all seasons at ETR and PMR are a function of layer thickness to a significantly larger power ( $n_1$  equals 0.64 at PMR and 0.62 at ETR) than has been observed in a few late summer profiles by Armendariz and Rider at White Sands ( $n_1 = 0.38$ ) and Essenwanger at Cape Kennedy ( $n_1 = 0.44$ ).

For a similar comparison of standard deviations of vector shear, as illustrated in Figure 4.2, the constant power of  $\Delta Z$ ,  $n_2$ , is also significantly larger for the PMR ( $n_2 = 0.68$ ) and ETR ( $n_2 = 0.62$ ) profiles. In addition, the existence of the constant D in Equation 4.2, which implies a deviation from a power law relation between  $\sigma_w$  and  $\Delta Z$ , that is large for  $\Delta Z$  small, is not supported by either Armendariz and Rider or the PMR and ETR Jimsphere data.

The significant variations noted above for the exponents  $n_1$  and  $n_2$  of the power law relations (Equations 1 and 2) which may possibly be partially related to season and method of observation is also noted when  $n_1$  and  $n_2$  are derived from data at 1 km altitude intervals. As illustrated in Figure 4.3,  $n_1$  tends to be smaller at altitudes above 12 km and  $n_2$  tends to decrease with altitude for the ETR profiles and is somewhat erratic for the PMR profiles. Similarly, as illustrated in Figure 4.4 the constants C and E generally increase with altitude again showing a relatively steady trend for the ETR sample.

#### 4.4 CONCLUSION

For this study emphasis has been given to statistics of wind shear magnitude

TABLE 4.2

MEANS AND STANDARD DEVIATIONS OF VECTOR SHEARS FOR VARIOUS LAYER THICKNESSES AND CONSTANTS C, E,  $n_1$ ,  
AND  $n_2$  OF EQUATIONS 4.1 AND 4.2 FOR CAPE KENNEDY JIMSPHERE PROFILES

| Z(km)   |                  | $\Delta Z(m)$ |      |      |      |      |       |       | No. of<br>Obs. | C     | E     | $n_1$ | $n_2$ |
|---------|------------------|---------------|------|------|------|------|-------|-------|----------------|-------|-------|-------|-------|
|         |                  | 50            | 100  | 400  | 800  | 1000 | 3000  | 5000  |                |       |       |       |       |
| 8       | Mean(m/sec)      | 0.59          | 0.99 | 2.62 | 4.05 | 4.64 | 9.79  | 14.12 | 1154           | 0.042 |       | 0.68  |       |
|         | Std. Dev.(m/sec) | 0.43          | 0.67 | 1.81 | 2.77 | 3.15 | 6.12  | 8.93  |                |       | 0.031 |       | 0.67  |
| 9       | M.               | 0.60          | 0.99 | 2.75 | 4.24 | 4.93 | 10.16 | 14.95 | 1139           | 0.041 |       | 0.69  |       |
|         | S.D.             | 0.43          | 0.66 | 1.80 | 2.89 | 3.31 | 6.38  | 9.17  |                |       | 0.028 |       | 0.70  |
| 10      | M.               | 0.65          | 1.05 | 2.83 | 4.49 | 5.22 | 10.44 | 15.37 | 1132           | 0.046 |       | 0.68  |       |
|         | S.D.             | 0.46          | 0.69 | 1.84 | 3.00 | 3.57 | 6.73  | 9.36  |                |       | 0.030 |       | 0.70  |
| 11      | M.               | 0.73          | 1.15 | 3.13 | 4.82 | 5.47 | 10.87 | 15.76 | 1119           | 0.055 |       | 0.67  |       |
|         | S.D.             | 0.61          | 0.87 | 2.27 | 3.42 | 3.81 | 7.26  | 9.73  |                |       | 0.050 |       | 0.63  |
| 12      | M.               | 0.82          | 1.30 | 3.47 | 5.46 | 6.20 | 11.25 | 15.98 | 1101           | 0.069 |       | 0.64  |       |
|         | S.D.             | 0.63          | 0.90 | 2.32 | 3.78 | 4.30 | 7.41  | 9.59  |                |       | 0.046 |       | 0.66  |
| 13      | M.               | 0.99          | 1.56 | 4.07 | 5.88 | 6.51 | 10.71 | 14.81 | 1073           | 0.110 |       | 0.58  |       |
|         | S.D.             | 0.78          | 1.08 | 2.73 | 3.87 | 4.23 | 6.98  | 8.76  |                |       | 0.078 |       | 0.58  |
| 14      | M.               | 1.17          | 1.88 | 5.02 | 7.11 | 7.60 | 10.05 | 12.02 | 1036           | 0.191 |       | 0.51  |       |
|         | S.D.             | 0.82          | 1.14 | 3.10 | 4.52 | 4.87 | 6.61  | 7.48  |                |       | 0.071 |       | 0.62  |
| 15      | M.               | 1.27          | 2.01 | 5.35 | 7.83 | 8.55 | 10.87 | 10.27 | 957            | 0.239 |       | 0.48  |       |
|         | S.D.             | 0.97          | 1.25 | 3.06 | 4.55 | 4.92 | 6.33  | 5.98  |                |       | 0.099 |       | 0.57  |
| 8-15 km |                  |               |      |      |      |      |       |       |                |       |       |       |       |
|         | M.               | 0.84          | 1.34 | 3.60 | 5.41 | 6.07 | 10.51 | 14.25 | 8708           | 0.082 |       | 0.62  |       |
|         | S.D.             | 0.70          | 0.99 | 2.58 | 3.84 | 4.23 | 6.76  | 8.94  |                |       | 0.061 |       | 0.62  |

TABLE 4.3

MEANS AND STANDARD DEVIATIONS OF VECTOR SHEARS FOR VARIOUS LAYER THICKNESSES AND CONSTANTS C, E,  $n_1$ ,  
AND  $n_2$  OF EQUATIONS 4.1 AND 4.2 FOR POINT MUGU JIMSPHERE PROFILES

| Z(km)   |                   | $\Delta Z(m)$ |      |      |      |      |       |       | No. of<br>Obs. | C     | E     | $n_1$ | $n_2$ |
|---------|-------------------|---------------|------|------|------|------|-------|-------|----------------|-------|-------|-------|-------|
|         |                   | 50            | 100  | 400  | 800  | 1000 | 3000  | 5000  |                |       |       |       |       |
| 8       | Mean(m/sec)       | 0.56          | 1.01 | 2.60 | 3.84 | 4.44 | 8.42  | 12.54 | 76             | 0.047 |       | 0.66  |       |
|         | Std. Dev. (m/sec) | 0.44          | 0.70 | 1.84 | 2.57 | 2.93 | 5.21  | 6.39  |                |       | 0.037 |       | 0.64  |
| 9       | M.                | 0.61          | 1.08 | 3.40 | 5.24 | 5.81 | 9.48  | 12.91 | 77             | 0.054 |       | 0.66  |       |
|         | S.D.              | 0.47          | 0.79 | .87  | 4.41 | 4.77 | 7.03  | 8.03  |                |       | 0.021 |       | 0.80  |
| 10      | M.                | 1.00          | 1.74 | 4.90 | 7.75 | 8.88 | 14.37 | 17.69 | 77             | 0.098 |       | 0.63  |       |
|         | S.D.              | 0.68          | 1.24 | 4.08 | 6.76 | 7.91 | 9.56  | 9.78  |                |       | 0.029 |       | 0.82  |
| 11      | M.                | 0.98          | 1.46 | 3.94 | 5.93 | 7.33 | 18.32 | 21.71 | 80             | 0.061 |       | 0.70  |       |
|         | S.D.              | 0.90          | 1.20 | 2.58 | 3.90 | 5.22 | 10.87 | 11.45 |                |       | 0.093 |       | 0.57  |
| 12      | M.                | 0.85          | 1.41 | 3.55 | 6.00 | 7.23 | 17.07 | 21.77 | 80             | 0.051 |       | 0.72  |       |
|         | S.D.              | 0.54          | 0.81 | 2.25 | 3.23 | 3.72 | 10.15 | 10.93 |                |       | 0.042 |       | 0.65  |
| 13      | M.                | 0.97          | 1.71 | 4.28 | 6.18 | 6.87 | 12.52 | 19.40 | 81             | 0.091 |       | 0.63  |       |
|         | S.D.              | 0.52          | 0.89 | 2.32 | 3.85 | 4.54 | 6.43  | 8.85  |                |       | 0.032 |       | 0.72  |
| 14      | M.                | 1.10          | 1.90 | 5.13 | 6.79 | 7.48 | 12.79 | 15.86 | 80             | 0.135 |       | 0.58  |       |
|         | S.D.              | 0.68          | 0.92 | 2.59 | 3.67 | 4.13 | 7.65  | 8.31  |                |       | 0.056 |       | 0.63  |
| 15      | M.                | 1.17          | 1.85 | 5.30 | 6.29 | 6.91 | 12.66 | 13.56 | 76             | 0.160 |       | 0.54  |       |
|         | S.D.              | 0.61          | 1.00 | 2.50 | 3.38 | 3.31 | 6.74  | 8.07  |                |       | 0.066 |       | 0.59  |
| 8-15 km |                   |               |      |      |      |      |       |       |                |       |       |       |       |
|         | M.                | 0.91          | 1.52 | 4.14 | 6.01 | 6.88 | 13.21 | 16.99 | 627            | 0.081 |       | 0.64  |       |
|         | S.D.              | 0.66          | 1.01 | 2.84 | 2.84 | 4.26 | 4.93  | 8.76  | 980            |       | 0.045 |       | 0.68  |

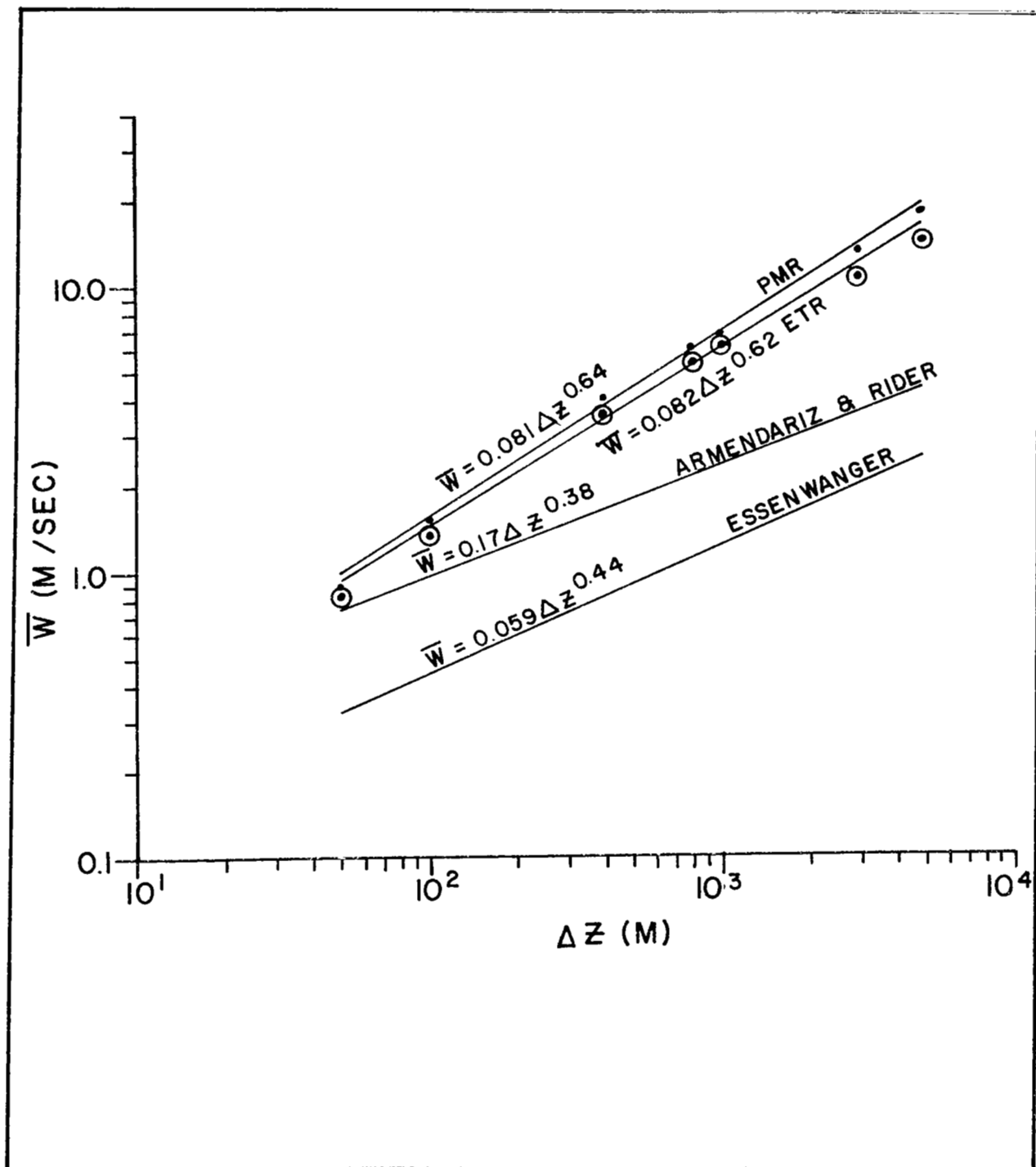


Figure 4.1 Mean Vector Shear as a Function of Layer Thickness

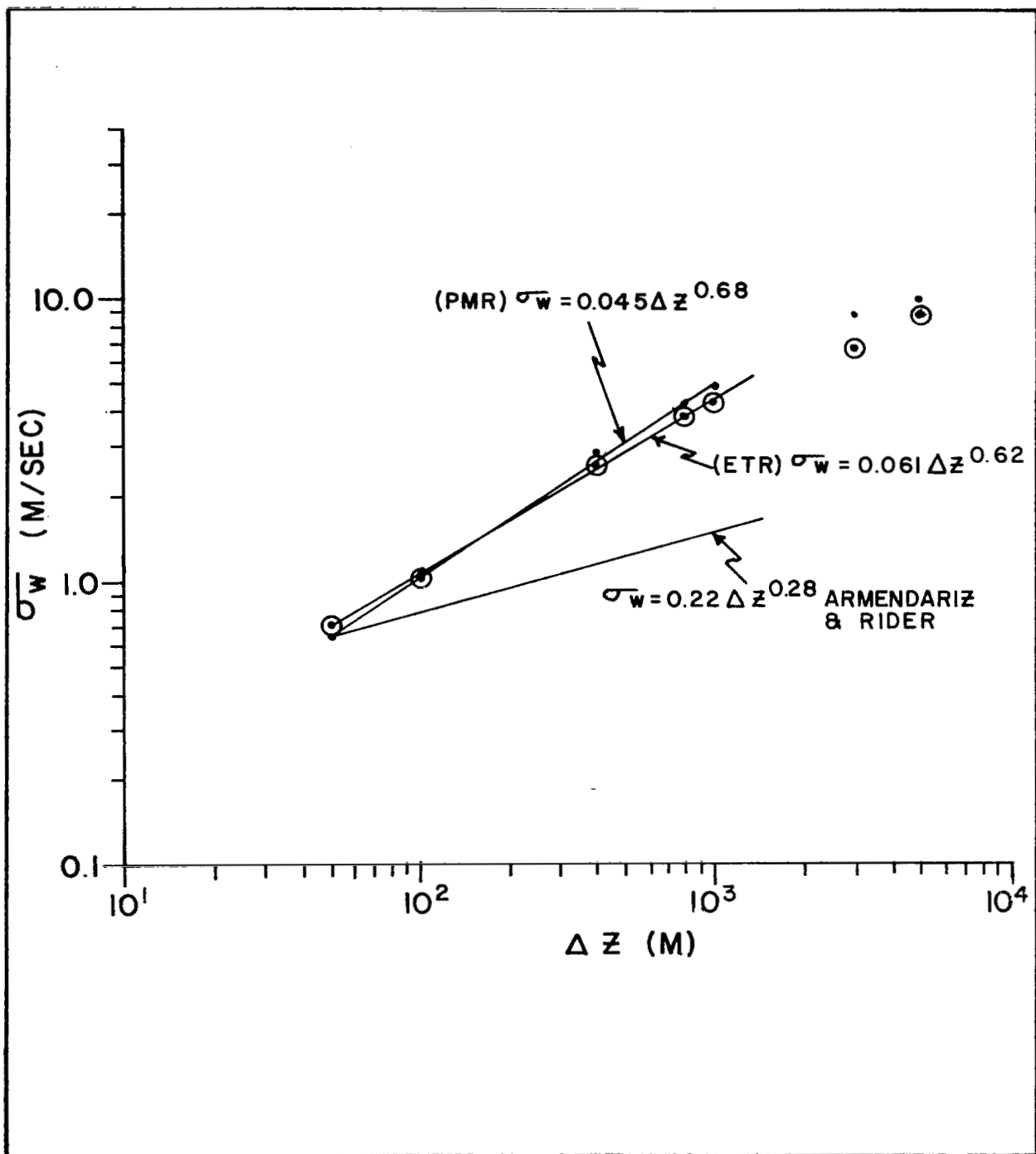


Figure 4.2 Standard Deviation of Vector Shear as a Function of Layer Thickness

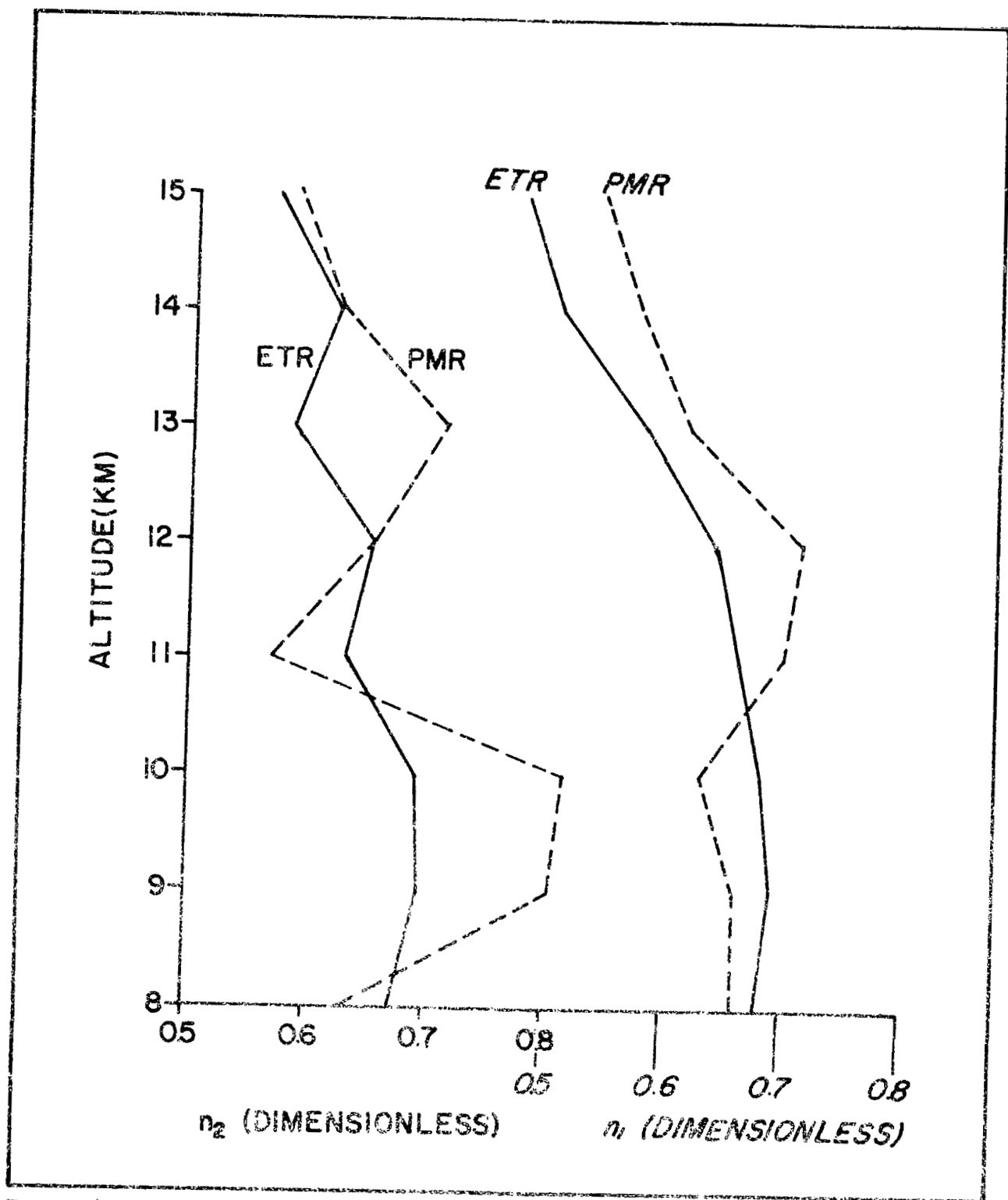


Figure 4.3  $n_1$ , of Equation 4.1 and  $n_2$  of Equation 4.2 as a Function of Altitude



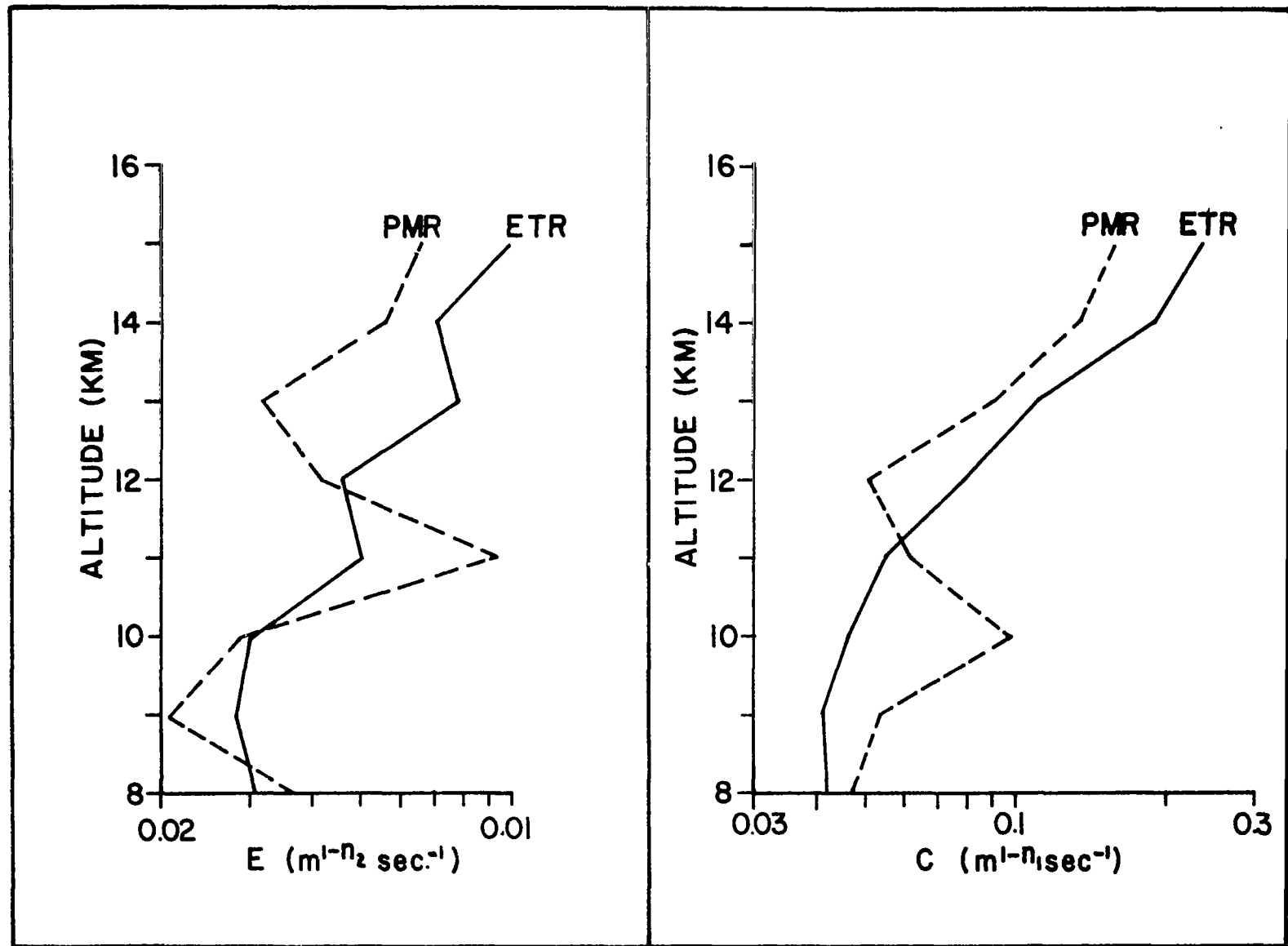


Figure 4.4 C of Equation 4.1 and E of Equation 4.2 as a Function of Altitude

computed from a relatively large sample of data obtained in all seasons. Therefore comparisons with other results derived from a few late summer soundings, which show poor agreement, further support the hypothesis that the constants of the proposed power law relations are a function of season; additional factors which may contribute to the poor agreement are systematic errors associated with the methods of observation (rockets, smooth balloons and Jimsphere) and differences in the altitude range of the observations which was 8 to 15 km for Jimsphere data and surface to 3.05 km for the White Sands data (Armendariz and Rider).

The ETR and PMR vector shear magnitudes, derived from sets of soundings which differ more in size than in their distribution by season, show a distinct similarity in the variation of means and standard deviations as a function of layer thickness.

## Section 5

### MATHEMATICAL REPRESENTATION OF GUST FUNCTIONS

#### 5.1 INTRODUCTION

In this section the aim is to develop a method of representing gust functions that are observed in detailed Jimsphere wind profiles. This will be achieved by utilizing a technique developed and used by Dutton (Ref. 2). The theory of the technique is discussed and a method of application is suggested.

#### 5.2 THEORY

Dutton used data obtained at low altitudes in a turbulent wind field. Four sets of data were obtained at each of six levels at Cape Kennedy below 150 meters. At each level wind direction and speed were measured at intervals of 1/10 sec over a long period of time. From this a vector wind velocity  $\vec{v}(t)$  was defined and an average vector  $\vec{v}$  was calculated according to

$$\vec{v} = \frac{1}{T} \int_0^T \vec{v}(t) dt \quad (5.1)$$

where  $T$ , the duration of some part of the experiment, is selected to include the portion of the wind record which has the largest gusts. Then the unit vector  $\vec{i}$  is taken along this wind direction and  $\vec{j}$  orthogonal to it. The longitudinal ( $u$ ) and lateral ( $v$ ) components of the turbulent wind are defined by:

$$\begin{aligned} u &= (\vec{v}(t) - \vec{u}) \cdot \vec{i} \\ v &= (\vec{v}(t) - \vec{v}) \cdot \vec{j} \end{aligned} \quad (5.2)$$

Thus, at each level, not only the wind direction and speed, but also the

u and v components are given as a function of time. For a particular run, at each level, ten largest gusts, for each component are chosen for every gust at each level. Assuming the validity of Taylor's hypothesis, a 3,000 ft. sample of data is extracted from the whole record in such a way that the gust falls in the center i.e. 1500 foot of data on each side of the gust. The aim is to find the general shape of these functions at all six levels. To this end a correlation matrix,  $R(X_i, X_j)$ ,  $[i, j = 1, \dots, N]$  is defined as follows: u and v are chosen at random points  $X_1 \dots, X_n$  on the 3,000 foot sample (in Dutton's case N is taken to be 50) for each of the 10 gust regions at each of the six levels. Let  $u_i$  and  $v_i$  be the u and v components of  $i^{\text{th}}$  gust. A correlation matrix is defined for the u component according to

$$R(X_i, X_j) = \frac{1}{10} \sum_{n=1}^{10} u_n(X_i) u_n(X_j) \quad (5.3)$$

This correlation matrix is used for application to the theory which will be developed next. A similar correlation matrix is calculated for the v component. The aim is to represent these gust functions by some set of known functions.

The mathematical problem to be solved is to find an economical method of representing these gusts. There is no reason to believe that any of the classical orthonormal series will be very efficient. The object is to find a set of orthonormal functions, which in some sense, to be decided later, are more like the functions we are trying to represent. For this purpose a theorem in proper orthogonal decomposition given by Loeve (Ref. 14) is used. Given a set of functions  $\{f\}$  defined on some finite domain, we would like to find a function  $\phi$  which in some sense is more like most of the functions in the set. So, we first have to agree on a definition of "likeness". We may be tempted to say  $\phi$  is more like f if the correlation between  $\phi$  and f is as large as possible i.e. try to maximize  $r = \int f(x) \phi(x) dx$ . But, since sign and magnitude are immaterial, and we only need relative magnitude, we may use the normalized quantity

$$p^2 = \frac{\left[ \int f(x) \phi(x) dx \right]^2}{\left[ \int f^2(x) dx \right] \left[ \int \phi^2(x) dx \right]} \quad (5.4)$$

It can be shown that  $p^2 \leq 1$ . Another measure of likeness may be minimizing of

$$D = \int [f - \phi]^2 dx \quad (5.5)$$

But  $\phi$  could be more like  $f$  than it is more "unlike"  $-f$ ; therefore we would like to redefine (5.5) so that  $\phi$  is acceptable if it either is like  $f$  or  $-f$ . Thus we find it more convenient to use

$$D = \int (f - \phi)^2 dx + \int (f + \phi)^2 dx \quad (5.6)$$

In (5.6) we can use the normalized form of  $f$  and  $\phi$ , denoted by  $f_n$  and  $\phi_n$  and rewrite (5.6) as

$$D_n = \int (f_n - \phi_n)^2 dx + \int (f_n + \phi_n)^2 dx \quad (5.7)$$

A simple calculation shows that

$$D_n = 4(1 - p^2) \quad (5.8)$$

Thus a maximum of  $E(p^2)$  gives a minimum of  $E(D_n)$ . Thus solving the problem, which involves finding a  $\phi$  to satisfy (5.4) is the same as finding a  $\phi$  to satisfy (5.7), and vice versa. Further any  $\phi$  which resembles  $f$  or  $-f$  will be acceptable. And finally, if we are able to produce such a  $\phi$ , it would be more "like" all the functions of the set simultaneously. Moreover, resemblance is in both senses of (5.4) and (5.7). It only remains to be seen whether there is such a  $\phi$ . A standard method of calculus of variations is used, i.e. it is assumed that there is a maximizing function  $\phi$  which induces a small variation  $\epsilon \delta \phi$  in  $\phi$ ;  $\phi + \epsilon \delta \phi$  is substituted into Equation (5.4) which is differentiated with respect to  $\epsilon$  at  $\epsilon = 0$ . It follows that

the equation

$$\int E [ f (x) f (y) ] \phi (x) dx = \bar{p}^2 \phi (y) \quad (5.9)$$

must be solved. This is a typical eigen value problem. Therefore, there is not only one, but a whole set of solutions to this integral equation. If we set  $\lambda_1, \lambda_2, \dots$  as possible eigen values with  $\lambda_1 \geq \lambda_2 \geq \dots$  we get corresponding eigen functions  $\phi_1, \phi_2, \dots$  upon setting

$$R (x,y) = E [f (x) f (y) ] \quad (5.10)$$

from (5.9) we get

$$\int R (x,y) \phi_n (x) dx = \lambda_n \phi_n (y) \quad (5.11)$$

An easy calculation shows that the functions  $\{ \phi_n \}$  form an orthogonal set under the inner product  $\langle f, g \rangle = \int f (x) g (x) dx$ . Upon normalization they form an orthonormal set. Since  $R (x,y)$  is defined on a finite domain, a possible choice for the eigen values is a countable set. In case an eigen value has multiplicity more than one, the associated eigen functions can be orthogonalized by the Gram-Schmidt method. Hence, the assumption that  $[ \phi_n ]$  form an orthonormal set is correct. Therefore, any function  $f$  of the set has a unique representation

$$f (x) = \sum_{n=1}^{\infty} a_n \phi_n (x) \quad (5.12)$$

where

$$a_n = \int f (x) \phi_n (x) dx \quad (5.13)$$

a straight forward calculation shows that

$$E ( a_n a_m ) = \lambda_n \delta_{m,n} \quad (5.14)$$

(where  $\delta_{m,n} = 0$  if  $m \neq n$  and  $= 1$  if  $m = n$ ). Thus the coefficients are uncorrelated across the set. The advantage of this analysis is that the tail end of the series is cut off in the formula (5.12) i.e. if we consider the first  $n$  terms in the power series expansion of  $f$ , we get close enough approximation of it. Of course the larger we choose  $n$ , the closer we get to the actual value of the function. But to get a fairly good estimation of the function,  $n$  does not have to be very large. For example, in the case of the data discussed in the earlier paragraph, if we take only the first eight eigen functions, they already explain at least 97 percent of the variance in each component. We can, in fact, calculate the error in the estimation of the function by the first  $n$  eigen functions; let  $e_n(f)$  be the error. It can be shown that

$$e_n(f) = \int [f]^2 dx - \sum_{n=1}^n [a_n]^2 \quad (5.15)$$

$$\text{Some further argument would lead to } \lim_{n \rightarrow \infty} e_n(f) = 0 \text{ i.e.} \quad (5.16)$$

the error can be made arbitrarily small.

This theory is used to analyze the data mentioned in the earlier paragraph. The correlation matrix (5.3) computed there is used in a summation form of Equation (5.11). A standard eigen value process is applied to the matrix and its eigen values and eigen functions are found. As mentioned earlier, by just using the first eight eigen functions, 97 percent of the variance in each component is explained.

### 5.3 APPLICATION

To apply the method outlined above it is suggested that a number of Jimsphere profiles closely separated in time be used. The time separation is analagous to the altitude separation of Dutton's data. Random points,  $x_i$ , are chosen to be at some fixed altitudes of the profiles. The number of  $x_i$ 's used is a function of the degree of accuracy required. For  $N$  profiles for the period

of interest the  $u$  and  $v$  components of the  $n^{\text{th}}$  profile at the altitude  $x_i$  are denoted by  $u_n(x_i)$  and  $v_n(x_i)$ . A correlation matrix is formed for the  $u$  component,  $R(x_i, x_j) = \frac{1}{N} \sum_{n=1}^N u_n(x_i) u_n(x_j)$ , and similarly for the  $v$  component. The derivation of the functions which describe the  $u$  and  $v$  components of each profile from each correlation matrix was described in the previous section.

A variation of the approach suggested above could be attempted by using several groups of closely spaced Jimsphere profiles. Within each group the average value of  $u$  and  $v$  would be calculated and substituted for  $u_n$  and  $v_n$  in the above analysis. Another alternative would be to take the vector  $\vec{i} u + \vec{j} v$  at each point (altitude)  $x_i$  and find its vector sum within each group which again would be substituted for  $u_n$  and  $v_n$  to find the correlation matrix and carry out the calculation. If the largest gusts are of interest a few of the largest gusts could be chosen in each group and the method could be applied to them. In this case, however, more care is needed. If we only look at the  $u$  and  $v$  components and choose the largest gusts, depending on the angle of the wind vector with respect to the  $u$  and  $v$  axis we could get different values for  $u$  and  $v$ . In other words two different wind vectors with the same magnitude could give completely different  $u$  and  $v$  components because the angles they make with the axis are not the same. Since we only seek the largest gusts, this may lead us to ignore some gusts which have appreciable magnitudes, but not very large  $u$  and  $v$  components, because of being situated at a "bad angle". This can be remedied if we first take the magnitude of the wind vectors and choose those with biggest magnitudes, and then go ahead and apply the above method to the  $u$  and  $v$  component of these chosen vectors.

#### 5.4 CONCLUSION

In applying Dutton's method for representing Jimsphere gust functions one should be careful in interpreting the results and have an understanding of



the extent and limitation of their use. Most important is that this analysis does not reveal significant information about the vertical variation of wind vectors. In addition, in interpreting the results of this analysis as it relates to space vehicles it should be understood that the Jimsphere views the atmosphere in about an hour and a half as it rises from the ground to 18 km compared to the spacecraft which covers the same vertical distance in 94 seconds. What the spacecraft sees requires a further interpretation of the results.

## Section 6

### CONCLUDING REMARKS AND RECOMMENDATIONS

#### 6.1 GUST STUDIES

Following the approach suggested in an earlier study of Jimsphere profiles (Ref. 1) a set of gust profiles have been derived in the time domain of a Saturn vehicle. An analysis of these gust profiles (Section 2) has revealed that their spectrum densities are generally smaller than spectrum densities of altitude profiles conventionally transformed to the time domain (Equation 2.7). It is suggested that the conventional transformation is invalid for time dependent vehicle velocities and that the spectrum densities of the time domain profiles derived in this study are the most accurate estimate of the spectrum of horizontal wind speeds seen by a Saturn vehicle. It is recommended that other aspects of these newly derived gust profiles be studied. Of particular interest is the variability of gust statistics; for example, the distribution functions and the distribution of spectrum densities of gusts computed for a number of vehicle flight time intervals should be stratified according to season and location (PMR, ETR, Wallops Island, White Sands) to partially explain their variability.

#### 6.2 ANALYSIS OF WIND SHEARS

The mean and standard deviation of vector shear magnitudes at altitudes between 8 and 15 km can be described by similar power law functions of layer thickness (Equations 4.1, 4.2) for Cape Kennedy and Point Mugu Jimsphere profiles. The significant difference between these functions and others derived from a few summer profiles obtained with different measurement techniques is partially attributed to a seasonal variation of the constants in the power law functions. It is recommended that future studies of the magnitude of vector shear establish the constants in the

power law functions for wind profiles grouped according to month or season; also recommended is a test of the hypothesis that the constants are correlated with the vector shear direction.

As suggested by Court (Ref. 1) the observed relations between means and extremes of shears to layer thickness is attributable to the decay of inter-level correlation of zonal and meridional wind speeds for increasing layer thickness; to test this hypothesis, it is suggested that Jimsphere profiles be used for a study of the decay of inter-level correlation beginning at 75 m layer thickness.

### 6.3 PROFILE SAMPLING

In Section 3, two validation tests of a method for selecting representative profile samples indicated that a) on the average the extremes were slightly over-estimated for the selection characteristics, and slightly under estimated for the test characteristics, and b) the spectra of any one of the five profile sub-sets selected from a random sequence of the parent population offer a fair approximation of that of the whole sample. It is recommended that further tests of the method be performed to establish how well profile samples obtained by using selection characteristics in fewer categories such as quartiles or quintiles, instead of deciles, represent the parent population.

## Section 7

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## Section 8

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MAXIMUM WIND SPEED AND MAGNITUDES OF VARIOUS VECTOR SHEARS, WITH  
CORRESPONDING ALTITUDES (TOP OF SHEAR LAYER), BETWEEN 4 AND 14  
KM IN 900 JIMSPHERE WIND PROFILES OVER CAPE KENNEDY.

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# APPENDIX I (Cont.)

| PROF<br>NO | MAXIMUM WIND<br>M/SEC | METER | +100MM SHEAR<br>M/SEC | METER | +100MM SHEAR<br>M/SEC | METER | +100MM SHEAR<br>M/SEC | METER | +100MM SHEAR<br>M/SEC | METER | +100MM SHEAR<br>M/SEC | METER | +100MM SHEAR<br>M/SEC | METER | +100MM SHEAR<br>M/SEC | METER | +100MM SHEAR<br>M/SEC | METER |
|------------|-----------------------|-------|-----------------------|-------|-----------------------|-------|-----------------------|-------|-----------------------|-------|-----------------------|-------|-----------------------|-------|-----------------------|-------|-----------------------|-------|
| 929        | 58.482                | 13252 | 3.721                 | 8558  | 3.853                 | 13675 | 17.338                | 8758  | 18.513                | 13725 | 8.541                 | 8675  | 11.317                | 13798 | 27.831                | 18725 | 17.481                | 5388  |
| 931        | 47.912                | 13475 | 5.727                 | 7988  | 4.985                 | 13788 | 12.195                | 8688  | 16.530                | 13558 | 7.058                 | 7888  | 6.138                 | 12698 | 26.847                | 18488 | 11.162                | 4588  |
| 932        | 47.923                | 13588 | 4.458                 | 13525 | 3.798                 | 13858 | 11.815                | 18858 | 9.982                 | 12958 | 7.141                 | 18888 | 9.345                 | 13975 | 24.451                | 18475 | 18.986                | 4275  |
| 933        | 58.644                | 12575 | 2.632                 | 11425 | 3.785                 | 13588 | 11.888                | 11758 | 18.354                | 13675 | 7.227                 | 11725 | 9.823                 | 13075 | 23.267                | 9525  | 8.888                 | 4275  |
| 934        | 49.725                | 13325 | 3.656                 | 8375  | 4.388                 | 12588 | 15.782                | 9788  | 9.531                 | 12758 | 10.278                | 8525  | 18.397                | 12575 | 29.768                | 9788  | 13.317                | 13358 |
| 937        | 41.821                | 12535 | 3.837                 | 4825  | 3.288                 | 13588 | 15.322                | 4358  | 18.588                | 13952 | 11.331                | 4888  | 6.432                 | 13658 | 21.843                | 5325  | 8.888                 | 13588 |
| 938        | 38.389                | 13775 | 4.824                 | 4425  | 1.815                 | 9853  | 9.884                 | 18775 | 4.383                 | 5425  | 8.845                 | 18288 | 3.335                 | 9888  | 19.517                | 9125  | 18.258                | 4888  |
| 948        | 22.529                | 8888  | 3.873                 | 5588  | 3.224                 | 8475  | 11.788                | 4858  | 12.451                | 4888  | 6.357                 | 5858  | 9.932                 | 8588  | 18.881                | 5825  | 8.228                 | 18925 |
| 947        | 27.453                | 14888 | 2.677                 | 15925 | 2.251                 | 13688 | 9.258                 | 13525 | 5.977                 | 11825 | 6.834                 | 7775  | 5.741                 | 11825 | 18.784                | 18358 | 5.878                 | 13575 |
| 944        | 24.948                | 11275 | 3.882                 | 18825 | 3.023                 | 13688 | 11.415                | 7288  | 5.974                 | 4788  | 7.789                 | 7225  | 5.268                 | 18325 | 22.831                | 7225  | 18.324                | 5725  |
| 946        | 21.428                | 12788 | 3.861                 | 12425 | 3.968                 | 13825 | 18.936                | 18858 | 7.555                 | 12788 | 7.143                 | 12675 | 7.681                 | 13325 | 14.597                | 18758 | 12.828                | 8788  |
| 948        | 25.814                | 11225 | 4.631                 | 12758 | 4.934                 | 12925 | 19.333                | 12588 | 17.386                | 12658 | 12.472                | 12825 | 8.723                 | 13225 | 22.895                | 12888 | 28.841                | 14388 |
| 949        | 13.948                | 13888 | 2.616                 | 13888 | 2.369                 | 13588 | 9.447                 | 13258 | 5.596                 | 12788 | 4.818                 | 12825 | 4.318                 | 18825 | 11.823                | 13288 | 9.586                 | 13458 |
| 951        | 41.262                | 12975 | 4.666                 | 11588 | 3.837                 | 13675 | 15.893                | 12575 | 15.362                | 14588 | 12.258                | 12888 | 12.217                | 13888 | 22.374                | 12325 | 12.992                | 11325 |
| 952        | 37.937                | 12425 | 3.789                 | 4358  | 5.211                 | 18888 | 16.177                | 4888  | 28.673                | 11558 | 12.995                | 11188 | 13.949                | 11825 | 24.684                | 4288  | 18.287                | 13488 |
| 953        | 36.889                | 12875 | 5.991                 | 4258  | 4.318                 | 12525 | 28.477                | 4525  | 13.102                | 12925 | 12.568                | 4358  | 18.912                | 12575 | 24.355                | 4925  | 14.834                | 4125  |
| 954        | 39.446                | 11758 | 5.581                 | 13825 | 3.948                 | 11988 | 14.123                | 8425  | 11.987                | 18758 | 8.988                 | 11758 | 7.756                 | 4825  | 25.543                | 8558  | 14.691                | 8188  |
| 955        | 31.419                | 12775 | 1.251                 | 11875 | 3.575                 | 18925 | 17.918                | 13325 | 12.556                | 18425 | 8.371                 | 12958 | 9.184                 | 13675 | 26.112                | 13388 | 25.871                | 13425 |
| 956        | 34.682                | 12975 | 2.974                 | 8388  | 8.868                 | 13188 | 14.884                | 12788 | 21.713                | 13975 | 1.646                 | 6275  | 13.588                | 13488 | 28.995                | 13888 | 18.755                | 13858 |
| 958        | 61.168                | 11888 | 4.445                 | 18775 | 6.753                 | 13788 | 17.717                | 13588 | 26.135                | 14888 | 18.119                | 12958 | 19.895                | 14888 | 22.824                | 5658  | 31.763                | 13488 |
| 968        | 43.544                | 11575 | 5.939                 | 5775  | 3.918                 | 12658 | 9.633                 | 13888 | 9.756                 | 13288 | 8.181                 | 13525 | 6.235                 | 12988 | 16.122                | 12888 | 3.584                 | 13425 |
| 961        | 43.882                | 13558 | 3.526                 | 6158  | 3.354                 | 13288 | 12.684                | 6775  | 6.187                 | 8825  | 18.514                | 6425  | 5.596                 | 11358 | 21.858                | 7175  | 8.888                 | 13425 |
| 962        | 52.822                | 13558 | 3.876                 | 8888  | 3.534                 | 13658 | 16.378                | 8558  | 6.458                 | 14888 | 9.833                 | 6125  | 5.894                 | 13858 | 28.431                | 6958  | 2.888                 | 13425 |
| 963        | 48.981                | 13375 | 3.199                 | 12925 | 3.818                 | 13658 | 13.255                | 11875 | 18.477                | 4725  | 6.931                 | 13225 | 7.562                 | 13625 | 28.253                | 13588 | 8.826                 | 8888  |
| 964        | 57.248                | 12588 | 5.122                 | 12588 | 2.732                 | 13425 | 16.258                | 12825 | 5.888                 | 4675  | 12.381                | 12675 | 6.333                 | 13525 | 25.768                | 12825 | 7.212                 | 5188  |
| 965        | 47.885                | 13375 | 3.744                 | 12358 | 2.489                 | 8188  | 16.714                | 12788 | 8.814                 | 13975 | 13.172                | 4125  | 4.595                 | 8375  | 30.155                | 13488 | 4.531                 | 5958  |
| 967        | 51.213                | 12575 | 3.971                 | 11288 | 2.467                 | 18558 | 18.677                | 11258 | 6.856                 | 14888 | 12.226                | 11258 | 5.446                 | 9838  | 37.664                | 12525 | 16.358                | 5325  |
| 971        | 29.465                | 14888 | 3.997                 | 11552 | 2.743                 | 4125  | 12.743                | 4288  | 4.913                 | 4858  | 8.697                 | 13375 | 5.988                 | 4225  | 21.367                | 4888  | 4.622                 | 6675  |
| 972        | 23.227                | 13675 | 5.187                 | 13925 | 4.326                 | 13988 | 15.844                | 12875 | 13.274                | 12888 | 12.111                | 12988 | 8.336                 | 13958 | 17.974                | 13688 | 15.339                | 5725  |
| 973        | 17.745                | 13558 | 4.859                 | 12158 | 2.958                 | 12675 | 7.282                 | 13725 | 6.987                 | 8175  | 5.654                 | 13288 | 6.182                 | 8858  | 10.312                | 10288 | 12.753                | 4875  |
| 974        | 15.422                | 12888 | 2.684                 | 14975 | 3.581                 | 12525 | 11.426                | 7358  | 13.759                | 14888 | 7.124                 | 13858 | 7.884                 | 12775 | 11.318                | 13225 | 15.145                | 14888 |
| 975        | 9.322                 | 13288 | 2.872                 | 12388 | 5.038                 | 18425 | 16.123                | 7888  | 16.123                | 7888  | 6.182                 | 7888  | 6.558                 | 13888 | 18.123                | 7888  | 8.461                 | 7888  |
| 976        | 15.358                | 12975 | 3.145                 | 9275  | 2.458                 | 7475  | 11.117                | 9852  | 12.168                | 8375  | 9.828                 | 9558  | 6.249                 | 7798  | 13.881                | 13275 | 18.127                | 12888 |
| 977        | 21.478                | 12758 | 4.633                 | 12175 | 3.774                 | 13453 | 16.244                | 12758 | 11.781                | 6588  | 11.163                | 12175 | 9.215                 | 13575 | 28.265                | 12758 | 15.895                | 18858 |
| 978        | 11.554                | 12125 | 3.119                 | 7958  | 2.771                 | 12388 | 9.386                 | 14288 | 3.741                 | 12925 | 6.519                 | 18875 | 5.853                 | 7858  | 17.791                | 18125 | 4.986                 | 4188  |
| 988        | 48.578                | 18888 | 3.521                 | 18125 | 3.729                 | 12658 | 10.188                | 7288  | 11.425                | 15275 | 8.545                 | 18788 | 8.562                 | 18858 | 18.339                | 4825  | 14.966                | 12825 |
| 981        | 46.389                | 9888  | 3.455                 | 13125 | 5.417                 | 13775 | 12.617                | 12248 | 15.888                | 12688 | 8.847                 | 9588  | 18.116                | 11688 | 23.187                | 11958 | 23.279                | 11875 |
| 982        | 57.834                | 11888 | 5.732                 | 18825 | 5.149                 | 13825 | 28.484                | 11375 | 11.856                | 12488 | 14.158                | 12625 | 9.172                 | 11252 | 27.183                | 5675  | 14.883                | 13975 |
| 983        | 57.788                | 12588 | 4.788                 | 18925 | 4.391                 | 12775 | 28.323                | 11858 | 13.337                | 13575 | 11.573                | 11175 | 11.054                | 13958 | 28.887                | 13975 | 8.288                 | 13975 |
| 984        | 59.374                | 12558 | 7.457                 | 11375 | 5.126                 | 12888 | 19.143                | 12588 | 18.888                | 13425 | 14.157                | 11175 | 9.841                 | 12758 | 28.998                | 12375 | 15.867                | 8788  |
| 982        | 45.388                | 12575 | 13.842                | 12525 | 7.148                 | 13475 | 14.883                | 11775 | 11.574                | 13525 | 16.878                | 12525 | 9.866                 | 13475 | 21.223                | 5888  | 12.888                | 12388 |
| 995        | 39.681                | 13575 | 3.458                 | 5675  | 3.821                 | 5125  | 12.829                | 12588 | 9.585                 | 4828  | 9.588                 | 5888  | 9.227                 | 5375  | 18.338                | 13688 | 12.296                | 5858  |
| 996        | 36.116                | 12552 | 2.681                 | 13575 | 3.195                 | 13688 | 12.871                | 12625 | 6.689                 | 13975 | 6.411                 | 12825 | 6.631                 | 13988 | 17.158                | 12758 | 8.916                 | 11588 |
| 1007       | 36.448                | 13588 | 3.188                 | 13825 | 3.248                 | 13975 | 18.168                | 8775  | 8.588                 | 18925 | 7.484                 | 13188 | 6.825                 | 14558 | 15.438                | 8558  | 8.888                 | 11588 |
| 1008       | 46.688                | 12388 | 3.541                 | 8475  | 4.191                 | 13488 | 18.948                | 8888  | 19.531                | 13558 | 9.325                 | 8758  | 18.673                | 13375 | 25.852                | 18525 | 14.188                | 12858 |
| 1082       | 39.356                | 13958 | 3.858                 | 5575  | 3.819                 | 14888 | 14.518                | 13475 | 14.586                | 13475 | 7.326                 | 13358 | 8.756                 | 5175  | 17.249                | 4888  | 8.888                 | 12558 |
| 1083       | 38.824                | 14888 | 2.884                 | 4925  | 2.913                 | 12588 | 12.372                | 4425  | 7.374                 | 13188 | 9.872                 | 4325  | 7.688                 | 12888 | 28.653                | 6775  | 11.898                | 13725 |
| 1084       | 49.185                | 12588 | 3.417                 | 13925 | 3.795                 | 13875 | 18.788                | 8875  | 17.557                | 13975 | 6.437                 | 4525  | 18.788                | 14888 | 24.464                | 18888 | 18.199                | 13975 |
| 1087       | 38.263                | 14888 | 3.717                 | 18788 | 3.487                 | 12958 | 18.488                | 8525  | 5.578                 | 6888  | 18.441                | 18758 | 5.617                 | 13275 | 24.928                | 8625  | 9.181                 | 5325  |
| 1088       | 53.444                | 11888 | 4.913                 | 14888 | 4.569                 | 13158 | 18.184                | 11875 | 19.484                | 13888 | 11.218                | 11875 | 14.587                | 13225 | 38.528                | 11875 | 11.847                | 5825  |
| 1089       | 58.873                | 12975 | 4.389                 | 8275  | 6.191                 | 13852 | 24.352                | 13188 | 28.573                | 13475 | 17.832                | 13188 | 13.132                | 13975 | 28.548                | 8925  | 18.188                | 13958 |
| 1018       | 58.285                | 13875 | 4.258                 | 13825 | 6.678                 | 13625 | 18.138                | 13825 | 19.666                | 14888 | 17.519                | 13158 | 19.388                | 13775 | 32.497                | 8888  | 8.889                 | 13375 |
| 1012       | 44.488                | 13888 | 3.611                 | 13888 | 3.821                 | 12675 | 16.318                | 13225 | 6.443                 | 5575  | 8.888                 | 12888 | 9.238                 | 13575 | 19.543                | 8588  | 11.791                | 5575  |
| 1013       | 44.968                | 12925 | 4.747                 | 12588 | 4.747                 | 12588 | 13.888                | 8525  | 4.888                 | 13888 | 8.338                 | 12888 | 4.874                 | 12388 | 17.664                | 8388  | 18.473                | 8888  |
| 1014       | 43.869                | 12588 | 4.428                 | 12888 | 4.269                 | 12158 | 13.888                | 12788 | 9.688                 | 13825 | 8.432                 | 12875 | 7.386                 | 12488 | 19.257                | 7825  | 9.181                 | 14888 |
| 1015       | 38.491                | 11875 | 4.756                 | 12788 | 4.459                 | 12675 | 11.433                | 6575  | 7.893                 | 12575 | 9.118                 | 11188 | 6.672                 | 12288 | 21.673                | 8275  | 11.792                | 4888  |
| 1016       | 23.437                | 13875 | 4.338                 | 13525 | 3.664                 | 13552 | 8.411                 | 18858 | 9.887                 | 14888 | 9.757                 | 13958 | 11.194                | 13858 | 15.661                | 8558  | 14.447                | 4888  |
| 1017       | 17.838                | 12958 | 3.872                 | 11325 | 4.142                 | 13258 | 9.663                 | 8958  | 9.547                 | 18258 | 9.717                 | 11388 | 12.459                | 13425 | 13.729                | 11558 | 18.112                | 11888 |
| 1018       | 16.691                | 12975 | 4.432                 | 18788 | 5.184                 | 13258 | 11.587                | 11875 | 12.579                | 11975 | 12.784                | 18975 | 18.537                | 13888 | 19.855                | 12788 | 13.383                | 18888 |
| 1019       | 23.255                | 12188 | 4.382                 | 8725  | 3.437                 | 12525 | 15.883                | 8888  | 16.883                | 7975  | 9.927                 | 7975  | 18.338                | 12958 | 28.226                | 18875 | 17.424                | 13858 |
| 1020       | 38.485                | 11575 | 4.887                 | 8675  | 4.487                 | 12625 | 14.388                | 6588  | 18.982                | 13225 | 4.955                 | 6358  | 9.558                 | 12825 | 19.257                | 11625 | 9.888                 | 14888 |
| 1022       | 39.488                | 13958 | 2.995                 | 13525 | 1.981                 | 4588  | 13.988                | 9275  | 11.574                | 4625  | 9.587                 | 9158  | 9.587                 | 9158  | 23.927                | 7825  | 9.                    |       |



## APPENDIX I (Cont.)

| PROT<br>NO | MAXIMUM WIND<br>M/SEC | 100MM SHEAR<br>METER | 100MM SHEAR<br>METER | 100MM SHEAR<br>METER | 100MM SHEAR<br>METER | 100MM SHEAR<br>METER | 100MM SHEAR<br>METER | 100MM SHEAR<br>METER | 100MM SHEAR<br>METER | 100MM SHEAR<br>METER | 100MM SHEAR<br>METER | 100MM SHEAR<br>METER | 100MM SHEAR<br>METER | 100MM SHEAR<br>METER | 100MM SHEAR<br>METER |       |        |       |
|------------|-----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|-------|--------|-------|
| 798        | 18.998                | 14388                | 2.512                | 5575                 | 2.665                | 6955                 | 5.912                | 13858                | 5.783                | 4258                 | 4.596                | 11888                | 4.191                | 4825                 | 8.858                | 14888 | 6.516  | 9588  |
| 799        | 11.249                | 11558                | 3.878                | 11688                | 3.744                | 7388                 | 8.779                | 11858                | 6.928                | 12975                | 6.666                | 11825                | 5.383                | 12475                | 9.991                | 11825 | 8.194  | 6558  |
| 800        | 13.389                | 13575                | 3.761                | 13525                | 2.827                | 13488                | 12.819               | 13958                | 12.282               | 13625                | 9.417                | 13675                | 8.218                | 13575                | 12.765               | 13958 | 8.518  | 8358  |
| 801        | 14.486                | 12558                | 4.522                | 14888                | 2.438                | 18258                | 18.533               | 12325                | 18.536               | 13788                | 7.799                | 11875                | 5.387                | 18475                | 11.884               | 8388  | 8.988  | 7888  |
| 802        | 12.396                | 11958                | 2.753                | 14888                | 2.439                | 13725                | 8.178                | 13988                | 8.895                | 13858                | 6.238                | 11858                | 4.893                | 13725                | 8.518                | 8825  | 8.691  | 7975  |
| 803        | 12.488                | 11725                | 2.585                | 13575                | 3.088                | 12958                | 6.838                | 11658                | 18.885               | 13858                | 5.548                | 13575                | 8.182                | 13925                | 11.558               | 11858 | 9.331  | 7788  |
| 804        | 15.868                | 12558                | 3.493                | 13525                | 3.958                | 13875                | 7.582                | 18888                | 7.838                | 13525                | 5.421                | 9925                 | 5.638                | 13625                | 12.469               | 9975  | 9.211  | 6788  |
| 805        | 15.868                | 5325                 | 2.896                | 12458                | 2.988                | 12325                | 11.838               | 13575                | 13.418               | 13625                | 7.996                | 13825                | 7.688                | 12625                | 14.482               | 13575 | 9.549  | 8275  |
| 806        | 16.838                | 8425                 | 2.771                | 18275                | 3.163                | 12975                | 9.585                | 18275                | 11.966               | 9575                 | 7.821                | 8325                 | 8.318                | 13225                | 13.588               | 8588  | 16.896 | 11358 |
| 807        | 18.295                | 4558                 | 2.155                | 12375                | 2.584                | 9175                 | 8.137                | 9888                 | 7.562                | 13858                | 5.793                | 9475                 | 4.957                | 13325                | 9.923                | 12688 | 11.749 | 9575  |
| 808        | 15.388                | 7575                 | 2.285                | 9175                 | 2.645                | 8158                 | 5.148                | 11358                | 7.881                | 8658                 | 4.985                | 13758                | 6.889                | 8175                 | 6.921                | 8875  | 13.358 | 12588 |
| 809        | 17.492                | 4988                 | 2.418                | 12175                | 2.461                | 18675                | 6.584                | 13858                | 18.978               | 18975                | 5.558                | 12475                | 5.717                | 13858                | 7.741                | 13758 | 12.488 | 12188 |
| 810        | 22.346                | 12558                | 3.228                | 7375                 | 3.896                | 13888                | 8.161                | 8275                 | 9.624                | 13888                | 5.748                | 18888                | 4.854                | 9958                 | 12.746               | 18225 | 9.979  | 5525  |
| 811        | 17.174                | 13588                | 3.367                | 12325                | 2.625                | 4675                 | 8.833                | 13858                | 8.885                | 13988                | 6.188                | 18675                | 4.697                | 7188                 | 17.437               | 12858 | 7.172  | 5288  |
| 812        | 17.818                | 12225                | 2.588                | 8588                 | 2.348                | 18875                | 12.614               | 18958                | 6.399                | 5888                 | 7.367                | 18358                | 7.383                | 18325                | 18.477               | 11758 | 8.371  | 6875  |
| 813        | 28.486                | 11188                | 2.684                | 18858                | 2.491                | 6225                 | 18.219               | 18525                | 7.979                | 6775                 | 6.147                | 18125                | 6.686                | 6225                 | 19.118               | 18788 | 11.884 | 8788  |
| 814        | 23.365                | 18375                | 3.184                | 9588                 | 2.832                | 6288                 | 12.988               | 18375                | 8.687                | 5125                 | 8.478                | 18175                | 6.526                | 13475                | 17.526               | 18358 | 13.879 | 7358  |
| 815        | 23.883                | 18525                | 2.613                | 9758                 | 2.636                | 13888                | 13.788               | 18675                | 9.685                | 8225                 | 7.183                | 18875                | 7.348                | 13888                | 17.648               | 11488 | 15.481 | 13175 |
| 816        | 22.358                | 18525                | 4.027                | 9358                 | 2.315                | 13788                | 13.846               | 18825                | 5.237                | 7258                 | 18.585               | 18875                | 5.885                | 9575                 | 15.811               | 18458 | 9.492  | 13875 |
| 817        | 18.588                | 9358                 | 2.685                | 6175                 | 2.495                | 13375                | 7.384                | 9525                 | 7.384                | 13725                | 5.234                | 8425                 | 7.884                | 13158                | 13.888               | 9575  | 13.922 | 12725 |
| 818        | 9.118                 | 11488                | 2.588                | 13825                | 2.948                | 13875                | 18.279               | 12958                | 11.219               | 12825                | 6.792                | 13675                | 6.848                | 13458                | 12.323               | 13825 | 12.441 | 13858 |
| 819        | 8.246                 | 5388                 | 2.981                | 11925                | 2.893                | 4725                 | 6.888                | 18488                | 8.882                | 6788                 | 4.663                | 11858                | 6.145                | 8975                 | 13.827               | 18988 | 12.357 | 18975 |
| 820        | 8.472                 | 5558                 | 2.776                | 13575                | 2.684                | 13925                | 8.864                | 9888                 | 9.395                | 12888                | 8.743                | 11888                | 6.373                | 11688                | 11.421               | 18788 | 12.346 | 18888 |
| 821        | 11.528                | 6775                 | 3.558                | 13558                | 5.171                | 13175                | 7.148                | 4888                 | 13.437               | 8325                 | 7.831                | 13575                | 11.691               | 13458                | 9.583                | 4888  | 13.764 | 9875  |
| 822        | 12.728                | 9125                 | 2.128                | 9588                 | 4.228                | 13888                | 9.425                | 9125                 | 9.128                | 18188                | 6.444                | 13988                | 6.831                | 13958                | 11.886               | 13825 | 12.987 | 12225 |
| 823        | 14.758                | 12725                | 2.173                | 13158                | 2.173                | 13158                | 9.982                | 13975                | 5.587                | 13158                | 5.587                | 13158                | 8.934                | 13158                | 8.934                | 13158 | 8.934  | 13158 |
| 824        | 13.128                | 11558                | 2.246                | 13788                | 2.689                | 11725                | 7.598                | 11358                | 7.919                | 12925                | 5.168                | 13975                | 6.178                | 11975                | 12.448               | 11358 | 6.427  | 7275  |
| 825        | 17.584                | 13525                | 2.138                | 11275                | 2.571                | 12788                | 6.623                | 18588                | 7.389                | 4225                 | 5.192                | 12325                | 4.661                | 12625                | 13.188               | 12425 | 11.169 | 4288  |
| 826        | 16.185                | 13558                | 3.231                | 8325                 | 3.564                | 13675                | 18.937               | 8725                 | 5.122                | 5658                 | 6.521                | 8325                 | 8.348                | 7725                 | 18.558               | 7858  | 8.859  | 4388  |
| 827        | 15.397                | 12358                | 2.724                | 4888                 | 1.954                | 14888                | 7.788                | 11675                | 6.924                | 14888                | 4.742                | 6175                 | 4.888                | 8825                 | 8.641                | 8488  | 8.222  | 4888  |
| 828        | 19.191                | 13888                | 3.624                | 4888                 | 2.527                | 5258                 | 11.663               | 4858                 | 8.284                | 8258                 | 6.488                | 4858                 | 7.885                | 8258                 | 16.261               | 6125  | 5.741  | 18258 |
| 829        | 28.742                | 11875                | 2.828                | 9758                 | 2.813                | 4325                 | 6.598                | 8825                 | 3.352                | 9775                 | 5.926                | 4588                 | 3.763                | 11325                | 11.618               | 18358 | 2.119  | 14888 |
| 830        | 15.545                | 7175                 | 3.363                | 13558                | 2.682                | 6225                 | 7.395                | 13925                | 6.724                | 1875                 | 5.588                | 8275                 | 4.941                | 9575                 | 8.147                | 4858  | 9.681  | 9875  |
| 831        | 16.813                | 11575                | 2.582                | 13725                | 2.588                | 13258                | 18.788               | 13725                | 9.488                | 13775                | 5.688                | 13958                | 5.837                | 13588                | 9.822                | 6858  | 4.739  | 9288  |
| 832        | 18.382                | 11525                | 1.925                | 9525                 | 3.243                | 13275                | 6.457                | 13425                | 6.656                | 13375                | 4.856                | 13488                | 4.958                | 13358                | 11.996               | 11725 | 7.547  | 11258 |
| 833        | 29.518                | 12588                | 4.215                | 5575                 | 4.887                | 12758                | 15.386               | 12888                | 17.228               | 12775                | 8.519                | 12558                | 18.993               | 13888                | 23.725               | 13825 | 24.824 | 13458 |
| 834        | 19.883                | 8525                 | 1.979                | 4125                 | 2.598                | 11758                | 18.612               | 4158                 | 7.963                | 12858                | 5.543                | 4158                 | 5.888                | 11988                | 17.267               | 6358  | 4.838  | 12858 |
| 835        | 18.317                | 13888                | 7.164                | 11388                | 2.129                | 11358                | 4.535                | 13588                | 5.340                | 12175                | 3.439                | 13558                | 5.584                | 11688                | 8.678                | 4425  | 4.887  | 11888 |
| 836        | 23.388                | 12725                | 1.864                | 13558                | 1.864                | 13558                | 6.758                | 4525                 | 5.975                | 12158                | 4.167                | 13858                | 3.978                | 8888                 | 9.453                | 9525  | 6.888  | 1358  |
| 837        | 27.291                | 14888                | 2.631                | 13558                | 2.969                | 12688                | 14.815               | 13575                | 16.888               | 13458                | 7.932                | 14888                | 8.271                | 12775                | 11.129               | 12858 | 9.815  | 13488 |
| 838        | 17.182                | 13875                | 4.528                | 13875                | 4.228                | 13888                | 11.766               | 14888                | 7.223                | 9575                 | 7.858                | 14888                | 3.739                | 11825                | 13.189               | 14888 | 8.277  | 11225 |
| 839        | 28.588                | 13558                | 2.389                | 11588                | 2.257                | 8825                 | 6.699                | 11525                | 4.835                | 9375                 | 3.575                | 4525                 | 4.164                | 8925                 | 8.977                | 4888  | 6.375  | 9788  |
| 840        | 28.545                | 13588                | 2.927                | 11525                | 2.389                | 7888                 | 7.298                | 9825                 | 5.837                | 6675                 | 6.355                | 13425                | 6.164                | 13475                | 18.999               | 5158  | 1.842  | 13775 |
| 841        | 28.586                | 6775                 | 5.529                | 6775                 | 8.979                | 6788                 | 9.286                | 6775                 | 5.993                | 7775                 | 9.524                | 6775                 | 6.153                | 7175                 | 12.161               | 4858  | 4.885  | 9775  |
| 842        | 31.714                | 18888                | 5.377                | 13458                | 5.366                | 13488                | 7.885                | 12788                | 11.251               | 13858                | 8.783                | 13788                | 11.218               | 13625                | 12.398               | 7288  | 9.155  | 13858 |
| 843        | 36.829                | 13175                | 2.589                | 7888                 | 1.842                | 11575                | 7.264                | 18788                | 4.902                | 12475                | 5.198                | 18788                | 4.737                | 9275                 | 11.384               | 12288 | 2.888  | 1358  |
| 844        | 39.214                | 13275                | 3.683                | 9888                 | 3.986                | 13625                | 13.628               | 9358                 | 14.276               | 14888                | 7.886                | 9325                 | 18.964               | 13858                | 22.737               | 18925 | 12.975 | 13888 |
| 845        | 39.572                | 13475                | 3.884                | 18158                | 5.122                | 14888                | 28.288               | 18758                | 14.587               | 14888                | 12.693               | 18258                | 13.548               | 14888                | 27.146               | 18975 | 15.147 | 14888 |
| 846        | 43.574                | 13788                | 5.346                | 13788                | 11.657               | 13888                | 18.786               | 13788                | 7.982                | 9775                 | 11.134               | 13425                | 8.843                | 13888                | 26.118               | 13788 | 4.398  | 4888  |
| 847        | 39.524                | 12575                | 2.855                | 4578                 | 2.637                | 13775                | 5.569                | 6475                 | 8.194                | 13558                | 6.737                | 6588                 | 4.448                | 4188                 | 28.317               | 8275  | 7.555  | 4888  |
| 848        | 23.543                | 9588                 | 2.246                | 13488                | 2.384                | 7125                 | 6.831                | 13575                | 7.447                | 7858                 | 3.948                | 13525                | 5.499                | 7325                 | 18.878               | 4825  | 7.129  | 12125 |
| 849        | 31.525                | 13788                | 3.127                | 11475                | 2.888                | 13888                | 7.836                | 11588                | 7.999                | 12858                | 5.964                | 11558                | 4.752                | 11788                | 12.694               | 12275 | 8.998  | 6888  |
| 850        | 32.417                | 13888                | 2.746                | 12375                | 2.755                | 7625                 | 18.137               | 18888                | 5.123                | 6458                 | 7.128                | 12558                | 4.111                | 5825                 | 16.297               | 18588 | 5.811  | 6858  |
| 851        | 33.198                | 12288                | 2.784                | 18275                | 3.354                | 4358                 | 12.429               | 18675                | 9.232                | 5188                 | 8.227                | 18525                | 8.389                | 4488                 | 15.184               | 12288 | 18.489 | 9358  |
| 852        | 15.681                | 13525                | 2.418                | 13888                | 2.428                | 9275                 | 8.492                | 11558                | 8.565                | 18488                | 6.549                | 12575                | 5.775                | 12525                | 11.172               | 9358  | 9.718  | 12475 |
| 853        | 27.581                | 7458                 | 5.157                | 7458                 | 5.586                | 7558                 | 8.829                | 7458                 | 18.825               | 8458                 | 7.681                | 4375                 | 7.835                | 7858                 | 19.377               | 6588  | 14.581 | 18458 |
| 854        | 24.388                | 9888                 | 2.421                | 8775                 | 3.115                | 9888                 | 9.894                | 4788                 | 18.482               | 11888                | 5.351                | 18375                | 7.389                | 9225                 | 11.154               | 6825  | 18.389 | 11888 |
| 855        | 26.844                | 9888                 | 4.747                | 9888                 | 3.984                | 9788                 | 11.581               | 7958                 | 13.563               | 12975                | 7.161                | 7958                 | 7.387                | 12975                | 19.858               | 9875  | 25.664 | 13225 |
| 856        | 13.521                | 8388                 | 2.973                | 8558                 | 3.296                | 4675                 | 12.887               | 5888                 | 12.372               | 4975                 | 6.345                | 7675                 | 6.488                | 11788                | 11.384               | 9125  | 17.434 | 5888  |
| 857        | 19.978                | 14888                | 4.331                | 13788                | 2.968                | 6625                 | 17.288               | 14888                | 9.171                | 9158                 | 12.141               | 13725                | 8.869                | 13525                | 14.547               | 14888 | 12.788 | 11225 |
| 858        | 7.754                 | 13325                | 2.282                | 8375                 | 1.931                | 6688                 | 5.923                | 7758                 | 6.733                | 7588                 | 4.331                | 7558                 | 3.785                | 6988                 | 9.195                | 8375  | 8.363  | 9525  |
| 859        | 18.935                | 14888                | 2.601                | 13525                | 3.639                | 9875                 | 8.923                | 9675                 | 5.694                | 6775                 | 6.723                | 13825                | 4.641                | 18825                | 13.337               | 11675 | 6.137  | 6588  |
| 860        | 26.153                | 14888                | 3.258                | 8775                 | 3.537                | 4675                 | 9.125                | 9325                 | 8.458                | 8888                 | 6.177                | 8825                 | 6.114                | 9225                 | 13.                  |       |        |       |

# APPENDIX I (Cont.)

| PROF<br>NO | MAXIMUM<br>METER | WIND<br>M/SEC | 1-100M<br>M/SEC | SHEAR<br>METER | 1-100M<br>M/SEC | SHEAR<br>METER | 1-100M<br>M/SEC | SHEAR<br>METER | 1-100M<br>M/SEC | SHEAR<br>METER | 1-100M<br>M/SEC | SHEAR<br>METER | 1-100M<br>M/SEC | SHEAR<br>METER | 1-100M<br>M/SEC | SHEAR<br>METER | 1-100M<br>M/SEC | SHEAR<br>METER |
|------------|------------------|---------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|
| 674        | 29.387           | 11725         | 2.395           | 12925          | 3.073           | 13875          | 7.919           | 5058           | 10.444          | 13920          | 4.395           | 9775           | 6.931           | 13958          | 14.297          | 11708          | 8.142           | 14200          |
| 675        | 27.937           | 13425         | 4.442           | 13425          | 5.642           | 13225          | 12.326          | 12375          | 13.715          | 13075          | 8.743           | 13475          | 10.255          | 13625          | 16.982          | 13458          | 18.438          | 13575          |
| 676        | 29.984           | 13425         | 3.462           | 13808          | 5.153           | 12775          | 14.238          | 10158          | 14.829          | 10375          | 8.772           | 10158          | 11.712          | 12958          | 22.363          | 13108          | 3.849           | 4488           |
| 677        | 29.412           | 13308         | 3.555           | 13908          | 3.688           | 13458          | 8.763           | 12325          | 6.977           | 13975          | 6.702           | 10225          | 7.485           | 13708          | 15.376          | 13308          | 12.566          | 4325           |
| 679        | 29.398           | 13958         | 4.737           | 13458          | 3.135           | 13788          | 13.909          | 12458          | 7.644           | 8675           | 8.188           | 12375          | 6.659           | 13825          | 15.672          | 13675          | 12.219          | 10375          |
| 680        | 21.567           | 13475         | 4.889           | 13425          | 2.413           | 7952           | 12.958          | 13858          | 7.182           | 8198           | 11.399          | 13458          | 5.586           | 12758          | 12.464          | 11358          | 13.729          | 11508          |
| 681        | 24.111           | 13575         | 2.883           | 13458          | 3.384           | 14082          | 8.437           | 14042          | 7.818           | 9458           | 8.831           | 13958          | 5.273           | 5275           | 10.898          | 7375           | 11.772          | 4988           |
| 682        | 29.838           | 11975         | 5.097           | 6375           | 4.157           | 5775           | 12.478          | 10275          | 12.582          | 6775           | 7.686           | 9708           | 10.634          | 6158           | 20.445          | 8688           | 12.338          | 13508          |
| 683        | 30.417           | 12975         | 3.217           | 12958          | 6.112           | 13582          | 10.592          | 12675          | 19.457          | 13958          | 9.855           | 12225          | 14.699          | 13708          | 25.381          | 12958          | 9.986           | 6358           |
| 684        | 24.357           | 13508         | 2.911           | 6875           | 2.478           | 14228          | 9.237           | 9725           | 6.689           | 16225          | 6.916           | 6388           | 5.671           | 10708          | 17.272          | 13725          | 12.282          | 12575          |
| 685        | 23.574           | 9975          | 3.174           | 13775          | 3.193           | 13225          | 13.876          | 13875          | 14.261          | 14088          | 8.095           | 13788          | 7.753           | 13458          | 17.063          | 13898          | 10.357          | 14308          |
| 686        | 26.378           | 11588         | 3.989           | 13358          | 3.327           | 12725          | 12.216          | 9858           | 12.445          | 12088          | 6.288           | 12825          | 9.421           | 12758          | 19.536          | 9908           | 24.908          | 14808          |
| 687        | 19.278           | 13475         | 3.999           | 12758          | 3.239           | 12925          | 12.296          | 12425          | 6.418           | 10425          | 7.697           | 12808          | 6.869           | 13525          | 11.992          | 13475          | 6.704           | 6708           |
| 688        | 22.248           | 12888         | 2.989           | 13725          | 4.432           | 13225          | 4.789           | 7858           | 7.777           | 13125          | 4.478           | 7275           | 6.799           | 12558          | 8.410           | 9875           | 12.793          | 13582          |
| 689        | 28.567           | 12475         | 3.583           | 12775          | 4.781           | 12725          | 9.845           | 12925          | 13.746          | 13108          | 6.272           | 12375          | 11.977          | 12858          | 12.378          | 6425           | 13.456          | 10988          |
| 690        | 38.407           | 12775         | 3.708           | 13458          | 4.569           | 11875          | 12.891          | 13758          | 20.878          | 12368          | 9.756           | 13475          | 13.587          | 12808          | 21.035          | 10208          | 35.627          | 13775          |
| 691        | 24.574           | 13225         | 3.699           | 12775          | 3.879           | 13475          | 7.687           | 13358          | 8.222           | 14088          | 7.204           | 12775          | 7.594           | 13688          | 11.256          | 7625           | 5.194           | 11808          |
| 692        | 25.382           | 11358         | 5.169           | 11557          | 4.482           | 13258          | 9.565           | 12675          | 6.965           | 13758          | 8.413           | 13468          | 9.471           | 12808          | 13.562          | 7858           | 7.428           | 13308          |
| 693        | 23.776           | 13975         | 3.682           | 13475          | 3.804           | 13325          | 9.944           | 5768           | 8.469           | 12725          | 11.051          | 13658          | 9.344           | 13575          | 17.047          | 10858          | 7.893           | 9125           |
| 694        | 26.579           | 13975         | 5.792           | 13368          | 5.897           | 5182           | 12.715          | 13808          | 13.322          | 4308           | 11.992          | 14208          | 7.573           | 5308           | 17.569          | 13975          | 9.117           | 13758          |
| 695        | 45.168           | 13108         | 5.424           | 12888          | 4.395           | 11225          | 24.932          | 13747          | 23.823          | 14028          | 15.753          | 13925          | 19.966          | 13508          | 24.648          | 13808          | 12.712          | 14082          |
| 696        | 39.249           | 13375         | 4.123           | 13258          | 5.474           | 13858          | 12.664          | 12725          | 15.731          | 14008          | 10.474          | 13275          | 15.147          | 13575          | 22.066          | 13275          | 6.651           | 14088          |
| 697        | 37.874           | 13475         | 4.282           | 13425          | 5.521           | 13975          | 9.626           | 13458          | 13.208          | 14088          | 9.569           | 13475          | 15.688          | 13975          | 24.749          | 13458          | 8.134           | 8558           |
| 699        | 56.997           | 12775         | 4.265           | 11425          | 4.264           | 13975          | 18.881          | 11152          | 12.268          | 14088          | 7.773           | 13025          | 10.244          | 14088          | 34.513          | 11158          | 13.299          | 14088          |
| 703        | 47.225           | 12775         | 4.358           | 13508          | 6.557           | 13758          | 21.338          | 12358          | 10.154          | 10725          | 10.348          | 11958          | 12.696          | 13908          | 45.292          | 12988          | 13.014          | 4808           |
| 704        | 54.245           | 13558         | 3.667           | 11425          | 4.788           | 13908          | 24.504          | 11925          | 19.316          | 14088          | 10.346          | 11325          | 11.177          | 14088          | 41.576          | 11988          | 11.969          | 4258           |
| 705        | 37.867           | 13525         | 2.711           | 12375          | 2.886           | 7475           | 12.658          | 12675          | 6.752           | 7458           | 5.941           | 12675          | 4.288           | 14088          | 19.762          | 13525          | 13.293          | 4358           |
| 706        | 36.621           | 11725         | 3.523           | 13558          | 4.431           | 14088          | 12.658          | 13575          | 5.793           | 11275          | 5.985           | 11808          | 4.987           | 4925           | 24.458          | 10308          | 14.732          | 4325           |
| 708        | 39.898           | 11325         | 5.511           | 13725          | 4.297           | 13925          | 22.291          | 10825          | 20.888          | 13975          | 14.401          | 10775          | 13.359          | 13975          | 40.063          | 11388          | 10.907          | 13975          |
| 711        | 51.422           | 13575         | 5.544           | 10775          | 3.389           | 13825          | 18.545          | 9725           | 15.399          | 14088          | 9.265           | 9588           | 9.257           | 14088          | 39.044          | 11375          | 14.812          | 5925           |
| 712        | 52.246           | 13575         | 4.847           | 9225           | 3.566           | 13975          | 18.868          | 10758          | 16.788          | 14208          | 11.377          | 10758          | 10.081          | 13975          | 35.785          | 10725          | 21.731          | 13975          |
| 713        | 40.923           | 12775         | 4.237           | 10708          | 4.838           | 4175           | 16.595          | 9908           | 9.252           | 4825           | 10.839          | 9375           | 7.737           | 4308           | 32.139          | 10275          | 14.222          | 7488           |
| 715        | 38.907           | 13958         | 4.443           | 9108           | 3.389           | 9825           | 7.496           | 13525          | 7.249           | 11088          | 5.592           | 13275          | 6.599           | 13675          | 8.527           | 4175           | 11.481          | 13975          |
| 717        | 28.715           | 6525          | 2.585           | 6425           | 3.465           | 11275          | 8.748           | 12458          | 10.185          | 18725          | 6.164           | 11825          | 5.108           | 10225          | 10.097          | 13975          | 16.111          | 10975          |
| 718        | 16.702           | 4808          | 3.153           | 12975          | 2.733           | 13988          | 12.026          | 11175          | 7.884           | 14088          | 7.835           | 11725          | 6.101           | 14088          | 5.633           | 13258          | 8.389           | 7375           |
| 719        | 28.887           | 13258         | 2.692           | 11288          | 6.417           | 13758          | 12.798          | 13108          | 10.657          | 14048          | 5.877           | 13108          | 15.148          | 14088          | 22.091          | 13125          | 6.940           | 13808          |
| 721        | 29.981           | 12525         | 3.164           | 9498           | 2.355           | 9882           | 11.559          | 9725           | 6.333           | 4425           | 6.646           | 9375           | 4.668           | 7825           | 16.926          | 10288          | 7.764           | 6058           |
| 722        | 17.762           | 13525         | 4.593           | 13525          | 3.962           | 14288          | 12.045          | 13825          | 6.570           | 6325           | 12.816          | 13825          | 7.619           | 13525          | 11.638          | 11258          | 8.721           | 8358           |
| 723        | 17.956           | 10488         | 2.163           | 4275           | 4.781           | 13758          | 9.685           | 13658          | 9.164           | 4088           | 5.675           | 13625          | 8.222           | 14288          | 17.786          | 10488          | 13.390          | 14308          |
| 724        | 15.167           | 11588         | 3.879           | 13458          | 3.279           | 13975          | 7.637           | 8808           | 12.587          | 14088          | 6.266           | 13925          | 8.222           | 14288          | 13.658          | 11725          | 17.244          | 14088          |
| 725        | 33.585           | 13275         | 3.484           | 12708          | 4.628           | 13925          | 12.793          | 13375          | 7.476           | 9375           | 7.491           | 13125          | 7.447           | 14088          | 19.873          | 13775          | 14.860          | 14088          |
| 726        | 11.774           | 12925         | 3.468           | 4808           | 3.368           | 13988          | 11.835          | 4588           | 11.619          | 13808          | 8.921           | 4088           | 6.875           | 4225           | 9.624           | 13825          | 13.298          | 9598           |
| 727        | 18.812           | 12925         | 2.926           | 4425           | 3.985           | 13888          | 6.297           | 9875           | 6.194           | 13958          | 4.875           | 4225           | 4.935           | 6958           | 10.868          | 14088          | 9.408           | 4525           |
| 728        | 19.183           | 13375         | 3.468           | 13475          | 3.389           | 12558          | 6.686           | 13975          | 5.759           | 13958          | 4.935           | 13958          | 5.538           | 13975          | 9.522           | 9458           | 13.951          | 8358           |
| 729        | 15.260           | 13358         | 2.369           | 13108          | 2.184           | 13475          | 8.144           | 13175          | 8.628           | 12225          | 4.593           | 11858          | 5.538           | 13975          | 9.522           | 9458           | 13.951          | 8358           |
| 730        | 31.752           | 12475         | 2.767           | 10325          | 2.558           | 13988          | 13.583          | 10525          | 11.872          | 13975          | 7.738           | 10508          | 5.687           | 13958          | 25.439          | 10958          | 15.951          | 8358           |
| 731        | 28.367           | 11708         | 3.066           | 11475          | 3.359           | 13575          | 15.436          | 11625          | 10.847          | 13575          | 7.577           | 11808          | 7.617           | 13975          | 25.175          | 11925          | 8.071           | 4325           |
| 733        | 39.284           | 13488         | 3.357           | 13708          | 4.128           | 13975          | 13.962          | 13508          | 13.129          | 13925          | 9.163           | 13358          | 14.851          | 13925          | 27.998          | 11425          | 15.577          | 13958          |
| 734        | 39.678           | 13975         | 3.762           | 13975          | 1.922           | 7688           | 16.080          | 9775           | 4.446           | 6628           | 8.038           | 9175           | 3.464           | 6358           | 25.767          | 10975          | 14.272          | 5108           |
| 735        | 38.652           | 13525         | 2.894           | 7575           | 1.932           | 8458           | 9.357           | 7875           | 9.461           | 11708          | 6.151           | 7875           | 4.775           | 12775          | 14.789          | 7875           | 18.334          | 4925           |
| 736        | 24.597           | 12258         | 3.204           | 8388           | 2.386           | 6988           | 11.972          | 9058           | 6.732           | 7575           | 10.681          | 9008           | 5.381           | 7858           | 16.521          | 10875          | 11.444          | 7108           |
| 737        | 25.882           | 12258         | 2.588           | 8108           | 2.445           | 13575          | 8.214           | 9908           | 9.184           | 13108          | 5.470           | 9508           | 5.445           | 13688          | 13.183          | 9598           | 8.788           | 7508           |
| 738        | 29.594           | 13458         | 2.899           | 11275          | 3.812           | 13775          | 7.133           | 10825          | 7.082           | 14088          | 5.426           | 9858           | 8.507           | 14088          | 11.137          | 11758          | 6.305           | 6325           |
| 739        | 24.944           | 6125          | 13.899          | 8125           | 12.864          | 6225           | 12.726          | 5125           | 13.476          | 1275           | 12.371          | 6125           | 13.027          | 6525           | 10.715          | 6125           | 13.451          | 9125           |
| 740        | 24.371           | 13458         | 3.914           | 4175           | 2.615           | 7708           | 4.728           | 12275          | 5.086           | 4308           | 4.564           | 4308           | 4.218           | 7758           | 4.964           | 13525          | 7.106           | 7858           |
| 741        | 24.954           | 12775         | 1.988           | 13552          | 2.016           | 5975           | 6.128           | 5548           | 6.618           | 13688          | 4.713           | 4988           | 4.548           | 12558          | 11.622          | 5388           | 3.861           | 10158          |
| 743        | 27.171           | 13525         | 3.717           | 13375          | 1.583           | 13925          | 7.376           | 13525          | 6.378           | 13175          | 8.256           | 13425          | 9.448           | 14088          | 11.878          | 13425          | 5.881           | 10208          |
| 744        | 28.878           | 7888          | 2.454           | 13975          | 3.002           | 13275          | 6.913           | 12125          | 4.718           | 13975          | 5.536           | 11975          | 7.465           | 13975          | 10.836          | 4825           | 6.193           | 9975           |
| 745        | 18.878           | 7325          | 3.339           | 13975          | 4.108           | 14088          | 8.261           | 13575          | 8.711           | 12488          | 7.419           | 13975          | 5.404           | 7725           | 11.761          | 4425           | 11.845          | 13558          |
| 746        | 19.151           | 6358          | 5.974           | 13358          | 3.284           | 13288          | 14.188          | 13758          | 6.999           | 11875          | 11.691          | 13558          | 5.167           | 13975          | 12.866          | 4225           | 10.951          | 11475          |
| 747        | 19.669           | 6375          | 3.715           | 13958          | 2.865           | 13725          | 9.671           | 13958          | 8.329           | 13688          | 6.523           | 13125          | 7.438           | 13925          | 9.491           | 4625           | 11.428          | 5975           |
| 748        | 19.537           | 14088         | 3.836           | 5152           | 2.711           | 5258           | 13.336          | 13775          | 7.277           | 8975           | 7.441           | 13175          | 6.328           | 12575          | 13.379          | 5158           | 18.463</        |                |

## APPENDIX I (Cont.)

[illegible]

# APPENDIX I (Cont.)

| PROF<br>NO | MAXIMUM WIND<br>M/SEC | 190M<br>METER | SHEAR<br>METER | 190M<br>METER | SHEAR<br>METER | 190M<br>METER | SHEAR<br>METER | 190M<br>METER | SHEAR<br>METER | 190M<br>METER | SHEAR<br>METER | 190M<br>METER | SHEAR<br>METER | 190M<br>METER | SHEAR<br>METER | 190M<br>METER | SHEAR<br>METER |       |
|------------|-----------------------|---------------|----------------|---------------|----------------|---------------|----------------|---------------|----------------|---------------|----------------|---------------|----------------|---------------|----------------|---------------|----------------|-------|
| 395        | 38.221                | 13958         | 4.408          | 13725         | 4.954          | 14088         | 11.907         | 11375         | 12.411         | 12450         | 18.344         | 13825         | 7.989          | 11775         | 19.713         | 6525          | 18.263         | 5575  |
| 396        | 41.617                | 12208         | 2.596          | 11525         | 3.349          | 11708         | 15.741         | 11650         | 18.422         | 14088         | 6.896          | 11725         | 8.131          | 13725         | 24.142         | 11558         | 13.683         | 4388  |
| 397        | 41.997                | 13453         | 2.789          | 14543         | 4.912          | 13908         | 10.465         | 9775          | 9.236          | 14088         | 6.859          | 5988          | 9.083          | 14088         | 22.649         | 11825         | 14.973         | 5458  |
| 398        | 45.787                | 13823         | 4.651          | 13808         | 5.158          | 13523         | 12.844         | 18758         | 14.016         | 14088         | 8.117          | 13275         | 10.433         | 13808         | 23.369         | 12688         | 15.827         | 4325  |
| 400        | 36.343                | 13923         | 4.258          | 12675         | 3.476          | 14658         | 18.433         | 12188         | 6.587          | 18625         | 11.226         | 12725         | 7.208          | 13875         | 13.319         | 13925         | 5.266          | 18625 |
| 401        | 39.953                | 12188         | 1.626          | 12558         | 2.986          | 11208         | 12.849         | 5725          | 6.579          | 7150          | 6.118          | 5738          | 7.866          | 12858         | 18.234         | 13175         | 4.803          | 13525 |
| 402        | 41.255                | 12125         | 1.889          | 9725          | 2.935          | 12753         | 12.978         | 12325         | 6.675          | 13088         | 6.194          | 11125         | 6.426          | 14088         | 25.978         | 12325         | 2.875          | 13588 |
| 403        | 43.952                | 13175         | 3.480          | 11775         | 6.384          | 13553         | 14.938         | 12225         | 18.647         | 13978         | 10.484         | 12850         | 14.254         | 13825         | 27.811         | 12225         | 3.168          | 13775 |
| 404        | 27.132                | 12475         | 3.567          | 12475         | 3.786          | 5588          | 11.418         | 12175         | 8.946          | 13775         | 6.848          | 12188         | 7.261          | 13875         | 17.886         | 13475         | 7.442          | 6588  |
| 410        | 31.496                | 12275         | 2.864          | 11775         | 3.568          | 12908         | 12.375         | 8825          | 8.358          | 13475         | 8.383          | 12225         | 6.943          | 12675         | 14.735         | 6558          | 2.868          | 6588  |
| 411        | 42.947                | 11588         | 3.917          | 13775         | 5.875          | 13523         | 18.687         | 5575          | 7.393          | 13875         | 7.295          | 4975          | 9.962          | 13408         | 19.993         | 4268          | 3.674          | 13725 |
| 412        | 52.332                | 13975         | 4.525          | 4575          | 1.595          | 13925         | 11.447         | 5388          | 6.993          | 8898          | 7.990          | 4875          | 5.391          | 12698         | 23.992         | 6175          | 4.428          | 8958  |
| 413        | 68.652                | 13588         | 5.817          | 5125          | 3.202          | 14888         | 11.136         | 5458          | 4.332          | 13808         | 7.195          | 5158          | 7.321          | 13825         | 21.827         | 4088          | 3.804          | 8958  |
| 414        | 61.543                | 18925         | 3.247          | 13525         | 4.948          | 13443         | 10.841         | 5158          | 13.592         | 13225         | 2.785          | 4925          | 14.262         | 13625         | 30.333         | 5175          | 13.467         | 14588 |
| 415        | 53.944                | 13808         | 1.575          | 5775          | 5.282          | 13288         | 9.637          | 5975          | 10.410         | 13825         | 7.488          | 6358          | 12.892         | 13475         | 22.454         | 6888          | 15.765         | 4475  |
| 416        | 41.561                | 11588         | 3.267          | 9125          | 3.323          | 13753         | 12.127         | 9975          | 14.351         | 12268         | 7.731          | 9388          | 9.875          | 12088         | 22.342         | 11368         | 15.728         | 14488 |
| 417        | 42.811                | 12525         | 3.287          | 8125          | 3.199          | 13675         | 17.162         | 9058          | 18.686         | 13488         | 9.838          | 8475          | 8.878          | 13588         | 38.423         | 9375          | 15.897         | 4458  |
| 421        | 53.362                | 13588         | 4.754          | 13475         | 6.997          | 13775         | 18.421         | 13925         | 21.191         | 14088         | 11.518         | 11388         | 18.523         | 14088         | 24.839         | 7458          | 2.836          | 4258  |
| 422        | 53.959                | 13588         | 5.688          | 13808         | 7.245          | 13675         | 17.713         | 14588         | 17.713         | 14588         | 13.654         | 13575         | 12.358         | 14088         | 25.388         | 7775          | 2.888          | 4588  |
| 423        | 55.321                | 13588         | 4.988          | 13557         | 5.718          | 13475         | 18.443         | 13325         | 14.727         | 13588         | 13.637         | 13858         | 14.916         | 13725         | 16.997         | 13325         | 16.997         | 13325 |
| 424        | 44.768                | 18775         | 3.325          | 13558         | 3.278          | 13925         | 15.447         | 12888         | 14.751         | 13425         | 9.585          | 8825          | 7.475          | 13388         | 25.135         | 10225         | 17.317         | 15575 |
| 425        | 45.565                | 13475         | 3.386          | 13375         | 4.663          | 6528          | 9.625          | 8158          | 7.988          | 6653          | 6.584          | 7858          | 6.561          | 13875         | 33.958         | 4088          | 5.727          | 13375 |
| 426        | 38.488                | 12675         | 3.138          | 13488         | 3.573          | 14975         | 12.665         | 9158          | 7.484          | 8708          | 6.148          | 5588          | 6.674          | 13175         | 24.348         | 4658          | 5.775          | 13325 |
| 427        | 32.213                | 11925         | 3.935          | 11775         | 3.611          | 11648         | 8.181          | 11828         | 8.585          | 12458         | 7.465          | 11888         | 6.733          | 11748         | 14.728         | 8525          | 18.799         | 13558 |
| 428        | 23.695                | 12725         | 3.935          | 9475          | 3.493          | 13975         | 12.757         | 14258         | 7.281          | 11925         | 7.913          | 9725          | 4.763          | 13325         | 19.467         | 10825         | 4.712          | 13788 |
| 429        | 28.243                | 12488         | 3.317          | 12425         | 2.817          | 13588         | 7.235          | 12125         | 8.417          | 7475          | 4.364          | 11775         | 5.590          | 7858          | 14.181         | 9458          | 3.789          | 4588  |
| 430        | 28.829                | 13188         | 3.351          | 18125         | 4.777          | 12158         | 8.181          | 13588         | 7.428          | 5375          | 5.885          | 13888         | 5.224          | 13888         | 18.238         | 13388         | 3.733          | 9225  |
| 432        | 49.431                | 13588         | 1.537          | 5125          | 4.912          | 11775         | 11.172         | 9158          | 22.524         | 14088         | 6.449          | 9975          | 14.151         | 13475         | 26.498         | 12888         | 11.743         | 4488  |
| 433        | 47.463                | 12588         | 3.386          | 7125          | 4.406          | 13725         | 13.163         | 5858          | 19.222         | 13225         | 8.967          | 5928          | 11.866         | 13625         | 21.745         | 5888          | 13.778         | 13558 |
| 434        | 46.787                | 12453         | 3.189          | 11425         | 4.283          | 13823         | 12.222         | 5458          | 13.721         | 14088         | 6.965          | 7825          | 12.933         | 14088         | 19.729         | 7658          | 2.158          | 4525  |
| 435        | 58.239                | 18975         | 3.317          | 12458         | 4.413          | 11258         | 15.287         | 7475          | 13.513         | 13708         | 8.323          | 7158          | 8.297          | 11375         | 29.518         | 7575          | 22.417         | 13525 |
| 436        | 46.794                | 12208         | 3.391          | 13575         | 4.878          | 12975         | 15.211         | 12888         | 21.997         | 13875         | 8.345          | 11558         | 13.582         | 13258         | 28.147         | 12775         | 15.468         | 13258 |
| 437        | 47.478                | 12588         | 4.511          | 15575         | 5.707          | 12758         | 16.633         | 12848         | 23.739         | 13675         | 9.495          | 12575         | 13.198         | 13358         | 21.582         | 12688         | 7.979          | 13375 |
| 438        | 47.832                | 12725         | 4.399          | 11528         | 5.406          | 13348         | 14.565         | 12775         | 18.236         | 13525         | 11.765         | 13525         | 11.765         | 13525         | 21.765         | 12725         | 15.428         | 13375 |
| 440        | 44.185                | 13588         | 1.374          | 13925         | 6.937          | 13488         | 11.774         | 11958         | 7.988          | 13875         | 8.882          | 13575         | 11.201         | 13675         | 11.981         | 13775         | 15.888         | 14088 |
| 441        | 45.389                | 13588         | 3.682          | 12225         | 4.287          | 13475         | 9.978          | 12488         | 6.381          | 524           | 7.874          | 13688         | 14.161         | 14488         | 18.253         | 4425          | 5.782          | 13975 |
| 442        | 41.424                | 9375          | 4.266          | 12275         | 3.733          | 11725         | 12.432         | 4225          | 10.113         | 12458         | 7.880          | 12958         | 7.880          | 12958         | 17.572         | 4825          | 9.178          | 13375 |
| 443        | 53.335                | 12888         | 3.462          | 12775         | 5.192          | 13725         | 17.058         | 12688         | 13.114         | 13775         | 9.748          | 12625         | 11.862         | 13925         | 26.513         | 12988         | 18.247         | 14088 |
| 444        | 53.372                | 13488         | 3.178          | 6258          | 7.433          | 13875         | 12.353         | 13358         | 11.678         | 14088         | 6.573          | 6325          | 14.842         | 13808         | 33.919         | 6388          | 12.383         | 13958 |
| 446        | 58.355                | 13575         | 4.726          | 13375         | 4.158          | 14288         | 17.281         | 9175          | 15.821         | 12848         | 12.188         | 13675         | 12.188         | 13688         | 24.233         | 11125         | 9.430          | 12975 |
| 453        | 42.678                | 13375         | 3.513          | 11775         | 2.955          | 12975         | 12.363         | 12975         | 7.892          | 7875          | 5.948          | 12925         | 5.173          | 7488          | 18.473         | 13375         | 28.287         | 13375 |
| 454        | 46.178                | 12788         | 3.903          | 11225         | 3.255          | 13125         | 22.665         | 13188         | 9.856          | 8888          | 11.268         | 12888         | 7.248          | 13858         | 29.584         | 12725         | 12.218         | 7888  |
| 455        | 24.667                | 14888         | 3.785          | 11588         | 3.486          | 11658         | 11.114         | 12275         | 11.312         | 11925         | 8.851          | 11958         | 7.913          | 11925         | 16.538         | 12458         | 13.189         | 4188  |
| 456        | 29.924                | 13525         | 4.771          | 12175         | 2.886          | 13888         | 13.448         | 12725         | 7.553          | 13875         | 7.340          | 12658         | 7.545          | 13875         | 17.476         | 12688         | 13.888         | 7858  |
| 457        | 37.471                | 14888         | 5.569          | 13558         | 4.573          | 13157         | 16.982         | 13775         | 7.458          | 4575          | 9.875          | 13725         | 3.362          | 6425          | 17.543         | 14068         | 14.242         | 4558  |
| 459        | 43.808                | 13975         | 3.428          | 13425         | 3.133          | 9258          | 13.995         | 13775         | 11.127         | 5425          | 9.328          | 5525          | 7.454          | 6425          | 21.567         | 7475          | 17.492         | 4688  |
| 460        | 39.138                | 12988         | 3.859          | 12775         | 3.156          | 13425         | 13.638         | 12888         | 11.383         | 13425         | 13.487         | 12775         | 7.525          | 13225         | 19.778         | 6775          | 7.421          | 13875 |
| 461        | 53.345                | 13125         | 5.182          | 12775         | 7.288          | 13888         | 19.799         | 13188         | 24.441         | 14088         | 12.376         | 13208         | 19.291         | 13748         | 27.769         | 13188         | 7.998          | 13875 |
| 463        | 61.577                | 12958         | 4.398          | 13588         | 3.273          | 6488          | 15.949         | 8875          | 9.381          | 13875         | 8.137          | 13888         | 7.529          | 6888          | 25.184         | 7875          | 8.888          | 13575 |
| 465        | 54.638                | 12525         | 3.346          | 8125          | 5.175          | 8888          | 21.229         | 12858         | 18.868         | 13425         | 15.474         | 11788         | 18.174         | 8125          | 35.649         | 8275          | 11.144         | 9158  |
| 466        | 57.474                | 12775         | 3.428          | 6525          | 3.799          | 8852          | 24.689         | 6975          | 14.184         | 12975         | 16.165         | 6788          | 7.772          | 7975          | 38.886         | 7888          | 23.452         | 13588 |
| 467        | 48.472                | 11575         | 4.245          | 7925          | 3.282          | 12258         | 24.684         | 8858          | 18.878         | 13588         | 11.119         | 8188          | 6.838          | 8825          | 34.577         | 9875          | 14.347         | 4525  |
| 468        | 45.832                | 12588         | 4.296          | 13588         | 4.263          | 12848         | 13.438         | 9758          | 24.336         | 13558         | 11.252         | 13558         | 12.784         | 13875         | 24.385         | 9775          | 15.428         | 4325  |
| 469        | 59.181                | 12525         | 4.399          | 7525          | 6.875          | 13988         | 17.444         | 8875          | 24.336         | 13875         | 15.787         | 7588          | 13.521         | 13588         | 31.888         | 9975          | 13.722         | 4875  |
| 470        | 57.381                | 13375         | 4.372          | 6775          | 4.398          | 14088         | 15.354         | 9258          | 3.486          | 13975         | 12.817         | 6775          | 11.256         | 13875         | 24.516         | 6875          | 8.438          | 14088 |
| 471        | 54.945                | 12558         | 5.187          | 13808         | 3.774          | 14348         | 11.296         | 8558          | 7.768          | 13808         | 7.512          | 7175          | 4.994          | 12558         | 23.417         | 9125          | 9.879          | 13588 |
| 474        | 66.183                | 9558          | 5.887          | 18175         | 4.413          | 12458         | 18.625         | 5458          | 10.443         | 14728         | 12.728         | 6575          | 15.063         | 12225         | 31.067         | 4775          | 19.761         | 12888 |
| 475        | 67.335                | 8775          | 4.776          | 4775          | 6.124          | 12848         | 14.351         | 11825         | 10.410         | 13825         | 14.223         | 11258         | 15.881         | 11558         | 38.944         | 7688          | 28.214         | 11558 |
| 476        | 58.421                | 18875         | 3.781          | 4175          | 4.161          | 11825         | 21.297         | 4425          | 16.413         | 11988         | 9.844          | 9825          | 11.023         | 11325         | 30.659         | 18988         | 23.792         | 13925 |
| 477        | 50.428                | 11557         | 4.287          | 18758         | 4.577          | 16675         | 11.114         | 11775         | 8.726          | 11558         | 12.297         | 10225         | 13.343         | 13788         | 26.115         | 4858          | 23.887         | 12725 |
| 478        | 73.197                | 11558         | 4.338          | 11325         | 5.947          | 12725         | 24.414         | 8275          | 25.538         | 13588         | 13.179         | 11558         | 12.784         | 14088         | 42.989         | 8725          | 28.139         | 13858 |
| 479        | 65.397                | 18858         | 5.311          | 13588         | 4.913          | 13258         | 11.114         | 11775         | 7.768          | 13808         | 11.465         | 11558         | 13.486         | 12458         | 18.986         | 7488          |                |       |

# APPENDIX I (Cont.)

| PROF<br>NO | MAXIMUM<br>M/SEC | WIND<br>METER | +100MM<br>M/SEC | SHEAR<br>METER | -100MM<br>M/SEC | SHEAR<br>METER | +100MM<br>M/SEC | SHEAR<br>METER | -100MM<br>M/SEC | SHEAR<br>METER | +100MM<br>M/SEC | SHEAR<br>METER | -100MM<br>M/SEC | SHEAR<br>METER | +100MM<br>M/SEC | SHEAR<br>METER | -100MM<br>M/SEC | SHEAR<br>METER |
|------------|------------------|---------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|
| 271        | 11.442           | 6175          | 3.648           | 6175           | 3.382           | 6275           | 7.668           | 6175           | 6.882           | 6175           | 5.778           | 8475           | 4.981           | 11509          | 7.316           | 6175           | 5.124           | 13775          |
| 272        | 11.443           | 5983          | 2.644           | 4558           | 2.380           | 13575          | 5.194           | 5350           | 5.995           | 6925           | 4.584           | 18925          | 4.489           | 13425          | 8.518           | 4858           | 9.294           | 13475          |
| 273        | 11.876           | 4575          | 5.360           | 5375           | 3.705           | 5675           | 8.249           | 12100          | 7.314           | 11825          | 4.802           | 5575           | 5.980           | 8575           | 13.651          | 12658          | 14.713          | 12125          |
| 275        | 8.778            | 6825          | 2.795           | 13558          | 2.442           | 7888           | 6.274           | 4788           | 6.863           | 7825           | 5.065           | 13988          | 4.037           | 6425           | 7.759           | 6850           | 8.868           | 13358          |
| 276        | 5.461            | 18475         | 1.869           | 8375           | 2.331           | 13358          | 6.587           | 8575           | 4.153           | 8888           | 3.881           | 18488          | 4.427           | 13529          | 6.618           | 18558          | 5.868           | 7775           |
| 277        | 17.248           | 12558         | 3.283           | 13488          | 2.336           | 12488          | 8.988           | 13658          | 11.221          | 13458          | 5.446           | 13588          | 6.233           | 12788          | 18.845          | 13775          | 9.972           | 4888           |
| 278        | 21.488           | 13825         | 7.336           | 13588          | 12.861          | 13458          | 9.131           | 13888          | 8.494           | 13888          | 8.494           | 12888          | 15.482          | 13425          | 13.586          | 11875          | 7.454           | 7825           |
| 279        | 11.247           | 13588         | 2.382           | 5158           | 2.085           | 7775           | 6.528           | 13858          | 6.578           | 13825          | 4.221           | 6588           | 3.843           | 6475           | 10.321          | 14888          | 6.667           | 4325           |
| 280        | 14.854           | 13888         | 2.894           | 7425           | 5.438           | 14888          | 8.289           | 13525          | 9.211           | 14888          | 4.847           | 13158          | 8.578           | 14888          | 12.198          | 18558          | 7.172           | 14888          |
| 281        | 5.385            | 5158          | 1.843           | 9375           | 1.878           | 9858           | 6.287           | 7425           | 7.358           | 6358           | 4.183           | 14888          | 3.988           | 6275           | 6.872           | 14888          | 5.342           | 6558           |
| 282        | 6.984            | 4275          | 3.251           | 9588           | 9.761           | 9788           | 6.392           | 9375           | 8.749           | 18888          | 8.796           | 9688           | 8.523           | 18888          | 7.816           | 9688           | 8.588           | 12888          |
| 283        | 5.818            | 4558          | 2.957           | 5925           | 1.565           | 5925           | 3.692           | 14888          | 5.825           | 5925           | 3.564           | 14888          | 3.954           | 7458           | 4.753           | 4888           | 5.688           | 9375           |
| 284        | 12.187           | 4788          | 3.966           | 12758          | 3.578           | 12858          | 5.956           | 13275          | 5.548           | 9825           | 5.587           | 13875          | 4.121           | 13975          | 9.941           | 13158          | 8.652           | 18558          |
| 287        | 28.973           | 13425         | 2.984           | 18788          | 1.713           | 5475           | 8.569           | 11825          | 4.817           | 4675           | 6.813           | 11175          | 3.884           | 4688           | 17.292          | 13725          | 4.723           | 7575           |
| 288        | 19.987           | 18375         | 2.763           | 13175          | 2.488           | 12988          | 9.246           | 13558          | 13.818          | 13225          | 6.454           | 12158          | 8.034           | 13288          | 12.935          | 9258           | 9.474           | 13275          |
| 289        | 14.941           | 6375          | 4.875           | 13188          | 2.714           | 12788          | 12.521          | 13575          | 12.894          | 12975          | 7.634           | 12525          | 7.532           | 12588          | 10.781          | 11475          | 12.431          | 8925           |
| 291        | 12.967           | 11988         | 2.891           | 13525          | 2.573           | 6875           | 8.288           | 13875          | 6.521           | 13488          | 6.351           | 13858          | 4.821           | 7158           | 11.562          | 18725          | 7.484           | 6558           |
| 292        | 9.971            | 13725         | 2.486           | 13358          | 2.727           | 12625          | 6.398           | 13275          | 5.396           | 9888           | 5.125           | 13725          | 3.843           | 7875           | 6.989           | 5688           | 8.588           | 4475           |
| 293        | 17.945           | 13158         | 2.771           | 12488          | 2.085           | 13575          | 18.412          | 12858          | 9.597           | 13975          | 5.723           | 12688          | 6.754           | 13658          | 11.859          | 13388          | 7.862           | 7525           |
| 294        | 16.487           | 14888         | 3.187           | 13525          | 1.871           | 9358           | 5.361           | 12388          | 4.594           | 1875           | 4.432           | 13875          | 11.276          | 12375          | 9.742           | 12375          | 3.742           | 12375          |
| 295        | 15.233           | 13158         | 4.441           | 13175          | 2.435           | 13275          | 12.438          | 11258          | 18.688          | 18888          | 9.366           | 13175          | 7.484           | 18758          | 28.855          | 13175          | 13.923          | 12525          |
| 296        | 16.678           | 14888         | 2.875           | 13575          | 2.558           | 13888          | 7.135           | 18525          | 3.975           | 11458          | 4.177           | 14888          | 5.276           | 7558           | 18.978          | 12588          | 9.128           | 5588           |
| 297        | 16.924           | 13475         | 2.880           | 6158           | 1.834           | 13625          | 8.365           | 13225          | 4.496           | 5588           | 5.223           | 12825          | 5.438           | 12888          | 11.285          | 13875          | 5.268           | 5925           |
| 298        | 11.737           | 18725         | 1.987           | 12325          | 2.185           | 12758          | 7.012           | 9788           | 6.188           | 13488          | 4.789           | 9725           | 6.311           | 12925          | 9.174           | 18175          | 7.213           | 6175           |
| 299        | 14.645           | 13725         | 3.939           | 13125          | 2.664           | 13858          | 8.811           | 12288          | 5.726           | 4288           | 5.186           | 11758          | 6.341           | 14888          | 13.382          | 13725          | 7.812           | 6175           |
| 300        | 16.338           | 13888         | 2.568           | 13125          | 6.618           | 12875          | 6.618           | 12875          | 4.440           | 8825           | 4.822           | 12875          | 3.269           | 4475           | 11.887          | 13575          | 4.245           | 4658           |
| 301        | 16.991           | 13588         | 2.746           | 8125           | 3.298           | 4558           | 7.873           | 8858           | 6.214           | 4758           | 5.285           | 9225           | 4.74            | 4825           | 9.812           | 11825          | 5.328           | 5888           |
| 303        | 19.182           | 13575         | 2.868           | 5475           | 2.367           | 5458           | 5.079           | 6275           | 6.282           | 5475           | 4.991           | 5658           | 4.788           | 5688           | 8.488           | 7825           | 9.132           | 7425           |
| 304        | 21.689           | 12488         | 2.629           | 12175          | 3.411           | 13675          | 6.442           | 8888           | 9.537           | 13975          | 5.181           | 12488          | 7.818           | 13758          | 18.544          | 18925          | 5.762           | 13775          |
| 305        | 18.785           | 13225         | 2.479           | 12575          | 3.189           | 13358          | 8.623           | 12725          | 4.698           | 18558          | 5.811           | 12758          | 4.821           | 12175          | 18.185          | 11758          | 5.418           | 7125           |
| 306        | 11.816           | 13888         | 1.736           | 13225          | 2.689           | 13858          | 4.454           | 9188           | 6.543           | 14888          | 3.888           | 4758           | 5.644           | 13975          | 7.268           | 11688          | 5.972           | 6125           |
| 307        | 18.114           | 9375          | 2.565           | 8888           | 2.828           | 18825          | 7.576           | 6575           | 11.338          | 18888          | 5.562           | 11825          | 6.157           | 18888          | 12.433          | 7458           | 9.439           | 11225          |
| 308        | 19.441           | 8325          | 3.963           | 8375           | 4.711           | 13225          | 11.981          | 8525           | 13.888          | 13658          | 8.893           | 8358           | 18.798          | 13588          | 11.488          | 12588          | 13.327          | 12175          |
| 310        | 17.998           | 11958         | 1.629           | 14158          | 3.127           | 12488          | 14.774          | 18458          | 18.881          | 1375           | 7.112           | 18358          | 9.976           | 12558          | 19.513          | 11725          | 12.687          | 13725          |
| 311        | 12.687           | 11988         | 2.303           | 9188           | 4.389           | 12888          | 7.666           | 9258           | 8.975           | 12475          | 6.543           | 13988          | 7.723           | 13858          | 14.148          | 11475          | 7.187           | 18125          |
| 313        | 14.756           | 13188         | 2.488           | 9275           | 2.614           | 8725           | 9.051           | 13875          | 6.565           | 14888          | 5.286           | 18188          | 4.935           | 14888          | 14.842          | 11175          | 6.522           | 6925           |
| 314        | 17.228           | 13575         | 5.817           | 12375          | 2.723           | 11725          | 14.182          | 12575          | 18.286          | 11758          | 11.333          | 12475          | 7.154           | 11175          | 26.474          | 13758          | 6.712           | 7888           |
| 315        | 34.545           | 6258          | 4.841           | 5525           | 4.966           | 9288           | 13.425          | 18858          | 15.336          | 18858          | 11.883          | 5825           | 9.112           | 9288           | 17.958          | 6875           | 31.347          | 18558          |
| 316        | 21.871           | 12525         | 2.444           | 4375           | 1.879           | 7825           | 11.614          | 12625          | 8.147           | 13625          | 7.874           | 14225          | 6.524           | 5888           | 15.727          | 12758          | 5.488           | 6125           |
| 319        | 25.558           | 13575         | 1.942           | 5458           | 4.776           | 5425           | 11.655          | 11275          | 7.347           | 7825           | 9.284           | 5788           | 9.938           | 7888           | 28.886          | 13658          | 12.562          | 5888           |
| 321        | 23.478           | 13788         | 4.438           | 14475          | 2.421           | 11858          | 8.435           | 11175          | 7.726           | 9588           | 9.378           | 18625          | 4.651           | 9425           | 11.259          | 4925           | 6.583           | 18375          |
| 322        | 28.981           | 14888         | 4.161           | 18558          | 3.318           | 9458           | 9.051           | 11258          | 6.534           | 18258          | 7.962           | 18825          | 6.038           | 13358          | 18.429          | 4888           | 5.708           | 11188          |
| 323        | 21.424           | 13975         | 3.478           | 4575           | 3.371           | 18488          | 18.823          | 12725          | 7.535           | 12175          | 7.941           | 13958          | 5.237           | 13425          | 12.637          | 4258           | 6.784           | 11375          |
| 324        | 21.228           | 18858         | 3.963           | 13475          | 2.782           | 13825          | 5.918           | 12275          | 6.848           | 12858          | 5.953           | 13225          | 5.693           | 13525          | 11.678          | 4925           | 4.412           | 13458          |
| 325        | 22.653           | 18825         | 3.188           | 18758          | 2.669           | 18925          | 4.981           | 12888          | 8.146           | 11888          | 5.239           | 13388          | 5.832           | 11175          | 18.439          | 4275           | 4.917           | 13158          |
| 326        | 25.886           | 18775         | 3.489           | 13788          | 3.162           | 13675          | 7.327           | 16775          | 9.865           | 11975          | 6.187           | 13825          | 5.533           | 12888          | 18.357          | 4275           | 4.568           | 13325          |
| 327        | 24.688           | 18958         | 3.711           | 13725          | 3.363           | 13788          | 6.562           | 18858          | 9.665           | 12175          | 4.884           | 13775          | 6.673           | 14888          | 18.859          | 8888           | 5.267           | 13325          |
| 328        | 15.693           | 7825          | 3.335           | 18188          | 2.678           | 9488           | 9.598           | 18775          | 9.278           | 9588           | 7.121           | 18225          | 5.348           | 9575           | 18.564          | 12625          | 9.387           | 4588           |
| 329        | 25.979           | 11275         | 2.886           | 18358          | 2.715           | 12858          | 8.921           | 11388          | 11.466          | 12275          | 5.229           | 18888          | 6.951           | 11675          | 11.815          | 7858           | 9.188           | 13858          |
| 330        | 77.674           | 14188         | 5.646           | 13775          | 4.223           | 18888          | 48.839          | 14888          | 4.897           | 4325           | 24.119          | 14888          | 11.295          | 18888          | 96.979          | 14888          | 5.494           | 4558           |
| 331        | 22.227           | 13558         | 4.448           | 12488          | 2.923           | 4275           | 15.888          | 12358          | 8.251           | 11288          | 9.128           | 12175          | 7.995           | 12548          | 29.787          | 13558          | 9.243           | 11888          |
| 332        | 17.755           | 13558         | 5.871           | 12158          | 4.387           | 11888          | 21.185          | 12225          | 28.219          | 12125          | 14.416          | 12125          | 12.821          | 12375          | 28.129          | 13558          | 22.284          | 12288          |
| 333        | 16.793           | 13525         | 5.538           | 14825          | 3.865           | 18575          | 19.924          | 11458          | 18.891          | 18775          | 11.797          | 18875          | 5.568           | 9425           | 19.957          | 13475          | 18.127          | 7225           |
| 334        | 9.978            | 13325         | 2.333           | 13525          | 2.638           | 13625          | 6.428           | 13325          | 6.887           | 12188          | 5.388           | 13275          | 4.467           | 11888          | 9.785           | 13475          | 7.811           | 11225          |
| 335        | 18.841           | 6188          | 2.182           | 13375          | 2.175           | 13725          | 4.626           | 13275          | 7.658           | 11525          | 4.285           | 13825          | 3.664           | 11825          | 5.319           | 9958           | 8.379           | 9958           |
| 336        | 15.357           | 13225         | 4.432           | 4888           | 4.684           | 4858           | 7.885           | 6775           | 6.319           | 4325           | 5.222           | 4725           | 6.186           | 4488           | 18.399          | 7325           | 8.274           | 4325           |
| 337        | 28.991           | 9358          | 1.195           | 13225          | 3.246           | 12858          | 9.542           | 5788           | 18.972          | 13658          | 5.419           | 5188           | 7.028           | 13558          | 11.577          | 7788           | 14.266          | 13748          |
| 348        | 16.788           | 8325          | 3.732           | 6575           | 1.893           | 13888          | 8.251           | 8258           | 12.168          | 8825           | 7.951           | 13388          | 8.485           | 7388           | 15.788          | 6725           | 14.444          | 6725           |
| 341        | 31.881           | 12575         | 4.988           | 12575          | 18.781          | 12575          | 18.781          | 12575          | 8.781           | 13375          | 13.779          | 12575          | 18.484          | 12575          | 28.187          | 12575          | 7.129           | 5588           |
| 342        | 18.717           | 13225         | 3.688           | 7558           | 3.344           | 13688          | 12.955          | 11888          | 8.598           | 9258           | 6.749           | 11288          | 6.662           | 13625          | 15.885          | 13288          | 9.423           | 7588           |
| 343        | 27.787           | 13625         | 2.613           | 9225           | 6.899           | 13975          | 11.843          | 9788           | 11.997          | 8958           | 7.823           | 9388           | 9.875           | 14888          | 14.831          | 11788          | 11.675          | 8888           |
| 344        | 24.424           | 14888         | 3.938           | 13888          | 3.298           | 8275           | 18.186          | 9725           | 13.318          | 8758           | 9.288           | 14888          | 9.784           | 8375           | 14.743          | 18725          | 18.699          | 8325           |
| 345        | 32.274           | 13525         | 4.695           | 8275           | 5.184           | 8875           | 18.186          | 12925          | 8.543           | 8675           | 7.884           | 13625          | 6.849           |                |                 |                |                 |                |

# APPENDIX I (Cont.)

| PROF NO | MAXIMUM WIND M/SEC | MINO METER | +100MM SHEAR M/SEC | -100MM SHEAR M/SEC | +100MM SHEAR M/SEC | -100MM SHEAR M/SEC | +100MM SHEAR M/SEC | -100MM SHEAR M/SEC | +100MM SHEAR M/SEC | -100MM SHEAR M/SEC | +100MM SHEAR M/SEC | -100MM SHEAR M/SEC | +100MM SHEAR M/SEC | -100MM SHEAR M/SEC | +100MM SHEAR M/SEC | -100MM SHEAR M/SEC |
|---------|--------------------|------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
| 140     | 26.396             | 13927      | 4.197              | 12558              | 3.789              | 12780              | 6.691              | 10825              | 7.288              | 13150              | 8.794              | 13980              | 9.338              | 13380              | 10.789             | 12625              |
| 141     | 46.115             | 14880      | 3.403              | 13375              | 3.773              | 13225              | 16.989             | 13775              | 17.504             | 13780              | 12.256             | 13525              | 12.628             | 13450              | 24.751             | 13880              |
| 142     | 43.558             | 14425      | 3.727              | 14125              | 2.613              | 13925              | 12.453             | 10150              | 6.946              | 11150              | 7.638              | 14150              | 4.065              | 12850              | 26.230             | 14150              |
| 143     | 45.435             | 13325      | 1.293              | 6400               | 2.937              | 9025               | 13.240             | 10550              | 6.940              | 12250              | 7.733              | 9950               | 6.891              | 9250               | 21.791             | 8575               |
| 144     | 48.265             | 13325      | 3.746              | 7425               | 3.705              | 13450              | 13.807             | 10675              | 8.478              | 14800              | 6.942              | 8250               | 8.361              | 13750              | 23.348             | 10880              |
| 146     | 49.571             | 13900      | 5.147              | 13575              | 3.195              | 6700               | 21.480             | 13725              | 8.282              | 7175               | 12.494             | 13550              | 6.155              | 6900               | 28.238             | 13975              |
| 147     | 46.371             | 13325      | 3.968              | 5900               | 4.385              | 6925               | 13.784             | 13225              | 12.429             | 7475               | 8.072              | 13150              | 9.566              | 7000               | 25.752             | 14000              |
| 148     | 45.295             | 13125      | 3.347              | 4100               | 4.822              | 4350               | 12.526             | 7500               | 9.013              | 5125               | 7.961              | 11350              | 8.601              | 4600               | 21.817             | 8225               |
| 149     | 54.421             | 13900      | 4.863              | 6700               | 2.857              | 9325               | 14.182             | 12750              | 5.215              | 10125              | 10.565             | 6050               | 4.166              | 8350               | 19.157             | 13425              |
| 150     | 55.765             | 13425      | 4.818              | 13575              | 7.282              | 13525              | 9.339              | 7250               | 9.457              | 8400               | 7.499              | 7380               | 10.945             | 13850              | 25.886             | 4080               |
| 151     | 38.575             | 13150      | 7.947              | 9375               | 3.295              | 13400              | 14.223             | 9825               | 13.615             | 14080              | 12.193             | 9375               | 8.385              | 13700              | 21.791             | 12125              |
| 152     | 48.728             | 13900      | 3.321              | 13775              | 2.419              | 9450               | 9.513              | 8475               | 8.545              | 4175               | 6.166              | 10850              | 3.995              | 9650               | 25.454             | 9600               |
| 153     | 24.137             | 13250      | 3.086              | 12900              | 4.924              | 12475              | 10.773             | 13325              | 11.150             | 14000              | 10.779             | 12825              | 12.138             | 13950              | 12.793             | 9625               |
| 154     | 23.373             | 13925      | 3.531              | 13375              | 2.534              | 13725              | 10.177             | 11125              | 5.328              | 12925              | 6.098              | 13625              | 4.618              | 14000              | 14.960             | 11175              |
| 155     | 25.213             | 12725      | 3.283              | 12775              | 3.521              | 12825              | 12.928             | 12475              | 13.821             | 13500              | 6.999              | 9175               | 9.852              | 13025              | 16.113             | 12725              |
| 156     | 27.487             | 13375      | 3.188              | 13300              | 6.745              | 13600              | 12.761             | 13400              | 6.466              | 9425               | 9.708              | 13250              | 15.233             | 13700              | 16.766             | 6625               |
| 157     | 24.321             | 12150      | 2.851              | 13525              | 3.673              | 12575              | 18.066             | 6300               | 10.754             | 13150              | 6.754              | 8225               | 6.718              | 12800              | 11.830             | 8225               |
| 158     | 18.082             | 9375       | 2.758              | 13550              | 3.949              | 6525               | 9.157              | 5950               | 9.067              | 11875              | 6.381              | 9325               | 5.042              | 13475              | 13.861             | 6100               |
| 159     | 37.389             | 12575      | 3.522              | 11425              | 5.194              | 13325              | 11.858             | 9700               | 12.082             | 13625              | 6.615              | 12500              | 8.888              | 13425              | 18.373             | 11575              |
| 160     | 38.687             | 13550      | 3.433              | 6550               | 2.613              | 12800              | 11.551             | 13400              | 6.483              | 12325              | 6.142              | 12425              | 7.858              | 12800              | 12.845             | 5525               |
| 162     | 34.361             | 13575      | 2.981              | 13550              | 3.124              | 9200               | 15.651             | 8675               | 5.429              | 13325              | 7.957              | 13825              | 5.169              | 13400              | 23.763             | 9725               |
| 165     | 38.269             | 13575      | 4.365              | 8500               | 3.257              | 9250               | 15.848             | 8750               | 9.270              | 9725               | 10.999             | 8375               | 8.936              | 13975              | 18.883             | 9850               |
| 166     | 27.796             | 13925      | 5.496              | 13525              | 3.183              | 4550               | 12.869             | 8450               | 7.176              | 10275              | 7.583              | 8425               | 6.224              | 13250              | 16.929             | 9425               |
| 167     | 25.187             | 14800      | 4.742              | 13475              | 3.343              | 11500              | 17.251             | 7600               | 7.568              | 13425              | 9.372              | 13950              | 7.198              | 13650              | 15.885             | 8550               |
| 168     | 26.068             | 12575      | 3.680              | 10800              | 2.917              | 5850               | 11.442             | 12675              | 7.794              | 7000               | 6.311              | 8075               | 21.511             | 13800              | 7.106              | 7500               |
| 169     | 21.968             | 14000      | 5.785              | 7100               | 2.927              | 7900               | 11.811             | 13700              | 9.958              | 13825              | 7.328              | 13750              | 6.434              | 13700              | 14.568             | 7850               |
| 171     | 10.099             | 11225      | 1.229              | 13900              | 2.094              | 4750               | 7.463              | 5100               | 7.547              | 5350               | 4.923              | 4975               | 6.675              | 4750               | 8.172              | 8625               |
| 173     | 15.612             | 12425      | 3.399              | 11125              | 1.969              | 5575               | 12.967             | 11825              | 7.082              | 5125               | 6.916              | 11425              | 5.773              | 5725               | 10.189             | 8725               |
| 174     | 15.556             | 14000      | 2.388              | 8325               | 3.319              | 8375               | 9.192              | 12325              | 8.051              | 9800               | 6.592              | 12800              | 5.132              | 7950               | 13.177             | 14000              |
| 175     | 26.197             | 13775      | 4.687              | 13825              | 3.794              | 11850              | 13.689             | 13850              | 6.763              | 4150               | 8.191              | 13975              | 4.442              | 11225              | 21.443             | 13975              |
| 178     | 18.486             | 14800      | 3.553              | 13525              | 2.788              | 4550               | 9.147              | 11875              | 6.766              | 4575               | 8.738              | 14000              | 5.187              | 4525               | 13.203             | 12700              |
| 179     | 22.778             | 13975      | 3.711              | 11425              | 3.599              | 11875              | 12.878             | 11950              | 6.387              | 4675               | 6.355              | 6550               | 6.598              | 11400              | 19.146             | 13950              |
| 180     | 21.777             | 13375      | 2.768              | 13925              | 2.255              | 13925              | 10.873             | 13925              | 6.531              | 14000              | 6.531              | 14000              | 6.531              | 14000              | 11.811             | 4575               |
| 181     | 16.494             | 13575      | 5.626              | 13575              | 2.493              | 4100               | 8.859              | 11325              | 9.197              | 12750              | 4.924              | 10675              | 5.069              | 12225              | 16.174             | 10925              |
| 187     | 23.145             | 14000      | 4.368              | 14000              | 2.399              | 7625               | 9.474              | 10275              | 9.753              | 8400               | 6.455              | 9675               | 5.174              | 7925               | 13.027             | 7175               |
| 188     | 24.968             | 13250      | 3.348              | 13150              | 4.515              | 13975              | 14.237             | 13175              | 10.413             | 12175              | 8.816              | 13150              | 8.465              | 14000              | 17.912             | 5200               |
| 189     | 25.117             | 12225      | 3.148              | 1175               | 3.739              | 12775              | 12.563             | 12225              | 11.925             | 13325              | 7.997              | 12225              | 6.859              | 12850              | 13.239             | 8800               |
| 190     | 14.399             | 7575       | 3.229              | 13000              | 2.891              | 4575               | 8.186              | 4400               | 11.474             | 4375               | 5.920              | 4650               | 6.035              | 4700               | 15.622             | 6350               |
| 191     | 22.518             | 12375      | 2.685              | 7575               | 1.847              | 8925               | 4.228              | 4900               | 5.674              | 13550              | 6.317              | 4825               | 3.566              | 12975              | 12.399             | 12575              |
| 193     | 20.359             | 12500      | 3.351              | 13375              | 3.913              | 14000              | 11.581             | 13750              | 8.551              | 12925              | 6.688              | 6725               | 10.711             | 12800              | 14.851             | 6175               |
| 204     | 28.858             | 13775      | 2.958              | 6400               | 2.921              | 7675               | 11.465             | 12700              | 6.201              | 9425               | 5.845              | 12525              | 4.867              | 6625               | 24.644             | 13725              |
| 196     | 31.624             | 12550      | 5.895              | 8175               | 4.568              | 14000              | 14.834             | 8275               | 11.211             | 13425              | 5.107              | 8275               | 7.927              | 13500              | 20.299             | 8300               |
| 197     | 31.687             | 13700      | 4.454              | 13575              | 5.913              | 13875              | 14.751             | 12500              | 9.787              | 13350              | 14.767             | 13425              | 11.699             | 14000              | 17.781             | 8100               |
| 198     | 20.743             | 14000      | 3.368              | 4350               | 2.787              | 13075              | 9.388              | 11625              | 14.792             | 4350               | 8.403              | 6350               | 7.824              | 4025               | 18.561             | 6500               |
| 199     | 22.982             | 13575      | 4.817              | 13775              | 2.922              | 13750              | 11.041             | 10300              | 4.774              | 8530               | 10.224             | 13500              | 7.086              | 13900              | 13.259             | 13675              |
| 200     | 26.871             | 13525      | 3.747              | 13150              | 3.747              | 13800              | 9.820              | 8775               | 7.813              | 12925              | 11.442             | 13375              | 8.257              | 12925              | 10.029             | 11825              |
| 201     | 31.768             | 12400      | 4.713              | 5400               | 3.991              | 5775               | 14.989             | 12400              | 12.195             | 13450              | 12.849             | 8200               | 10.316             | 13350              | 18.928             | 8225               |
| 202     | 12.166             | 13575      | 4.943              | 13125              | 7.538              | 9100               | 10.837             | 13300              | 8.637              | 5675               | 6.472              | 8275               | 5.752              | 6325               | 16.875             | 7875               |
| 204     | 28.858             | 13775      | 2.958              | 6400               | 2.921              | 7675               | 11.465             | 12700              | 6.201              | 9425               | 5.845              | 12525              | 4.867              | 6625               | 24.644             | 13725              |
| 205     | 14.878             | 8550       | 3.814              | 8550               | 2.632              | 9450               | 9.877              | 9525               | 6.985              | 10850              | 6.622              | 8925               | 5.288              | 9575               | 10.556             | 9750               |
| 207     | 16.190             | 14000      | 2.266              | 9450               | 3.313              | 9920               | 6.918              | 13225              | 7.613              | 9175               | 4.886              | 13950              | 6.584              | 8550               | 13.443             | 14000              |
| 208     | 16.243             | 4750       | 2.437              | 4425               | 2.469              | 4900               | 7.709              | 4900               | 6.196              | 6425               | 4.952              | 4300               | 4.317              | 5125               | 5.874              | 6650               |
| 209     | 18.474             | 12150      | 2.959              | 13125              | 3.352              | 13975              | 9.339              | 10850              | 9.927              | 9675               | 5.945              | 13375              | 7.811              | 14000              | 10.236             | 12450              |
| 210     | 17.137             | 13425      | 5.111              | 4975               | 3.315              | 7325               | 7.068              | 13650              | 7.739              | 9500               | 7.352              | 13375              | 5.077              | 10125              | 10.628             | 13425              |
| 213     | 22.333             | 12950      | 4.683              | 12900              | 3.576              | 9100               | 11.452             | 12275              | 10.103             | 13950              | 7.772              | 12150              | 6.589              | 13300              | 23.108             | 12950              |
| 216     | 17.111             | 13575      | 4.682              | 4475               | 4.346              | 9550               | 11.380             | 4900               | 11.354             | 5100               | 6.611              | 4625               | 9.402              | 4500               | 13.363             | 12300              |
| 217     | 20.747             | 13325      | 2.612              | 13375              | 4.941              | 13600              | 12.484             | 13325              | 7.861              | 14000              | 7.789              | 13325              | 12.938             | 13725              | 17.973             | 11725              |
| 219     | 14.147             | 5500       | 3.804              | 13775              | 3.478              | 14200              | 6.595              | 6125               | 13.000             | 13775              | 5.565              | 13775              | 6.752              | 13275              | 7.818              | 12800              |
| 221     | 16.522             | 13375      | 2.811              | 4950               | 3.653              | 4875               | 14.423             | 13550              | 7.148              | 11125              | 7.187              | 13750              | 7.900              | 5175               | 15.292             | 14000              |
| 222     | 22.928             | 12375      | 3.552              | 13525              | 3.112              | 4825               | 7.727              | 6500               | 18.897             | 15600              | 7.725              | 13600              | 6.797              | 12775              | 13.159             | 8400               |
| 223     | 13.896             | 11725      | 3.161              | 13100              | 3.138              | 12475              | 11.746             | 13875              | 6.822              | 12750              | 8.267              | 13600              | 5.898              | 8150               | 7.998              | 12875              |
| 224     | 12.333             | 12700      | 4.998              | 13575              | 2.933              | 13675              | 8.411              | 11575              | 6.548              | 6325               | 4.526              | 10925              | 5.426              | 13950              | 12.582             | 12700              |
| 225     | 14.442             | 14000      | 4.216              | 13175              | 4.352              | 13350              | 14.623             | 14000              | 7.148              | 12825              | 10.891             | 13975              | 6.867              | 12825              | 14.954             | 14000              |
| 227     | 17.294             | 11100      | 5.921              | 13552              | 2.963              | 13950              | 6.573              | 13925              | 7.191              | 13325              | 6.933              | 13725              | 6.611              | 13200              | 11.392             | 7850               |
| 228     | 19.365             | 13375      | 2.488              | 13275              | 3.486              | 13650              | 7.953              | 11875              | 6.968              | 13650              | 5.828              | 13275              | 7.798              | 13650              | 11.543             | 13275              |
| 229     | 29.745             | 13700      | 3.189              | 4250               | 2.544              | 13850              | 13.451             | 13700              | 5.187              | 13275              | 9.618              | 13625              | 4.638              | 10875              | 17.632             | 13725              |
| 230     | 14.214             | 13700      | 5.719              | 11575              | 3.437              | 13275              | 12.115             | 13775              | 5.673              | 13100              | 6.787              | 13725              | 4.988              | 12650              | 12.023             | 13700              |
| 231     | 9.588              | 13975      | 3.488              | 12575              | 2.883              | 12875              | 11.508             | 13100              | 12.292             | 12975              | 6.396              | 13000              | 5.637              | 12350              | 14.637             | 13525              |
| 232     | 16.395             | 13525      | 5.683              | 13475              | 5.972              | 12250              | 9.247              | 12500              | 10.191             | 13950              | 6.457              | 13525              | 8.318              | 12450              | 10.804             | 12850              |
| 233     | 31.875             | 12975      | 14.224             | 12475              | 19.391             | 13875              | 19.456             | 12975              | 28.967             | 1397               |                    |                    |                    |                    |                    |                    |

## APPENDIX I (Cont.)

[illegible]

# APPENDIX II

## COMPARISON OF CHARACTERISTICS OF 900 WIND PROFILES

Each 10 X 10 table in this Appendix gives the number of profiles which fell into the indicated deciles with respect to two critical (selection) or test (verification) characteristics. Thus, the upper left entry in the first table shows that in 32 of the 900 profiles both the maximum wind speed and the largest 100-meter positive shear were in the lowest deciles. The upper right figure indicates that 3 profiles in which the maximum wind speed was in the highest decile had no appreciable 100-meter positive shears, because the maximum such shears were in the lowest decile.

| MAX. WIND |       |       |       |       |       |       |       |       |       |        |
|-----------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| 100M S    | DEC.1 | DEC.2 | DEC.3 | DEC.4 | DEC.5 | DEC.6 | DEC.7 | DEC.8 | DEC.9 | DEC.10 |
| 1         | 12    | 16    | 13    | 6     | 4     | 3     | 4     | 5     | 4     | 3      |
| 2         | 28    | 14    | 18    | 11    | 4     | 5     | 4     | 5     | 3     | 6      |
| 3         | 9     | 14    | 16    | 9     | 9     | 5     | 10    | 5     | 3     | 6      |
| 4         | 9     | 12    | 14    | 9     | 11    | 4     | 7     | 8     | 10    | 6      |
| 5         | 8     | 16    | 9     | 10    | 9     | 7     | 10    | 7     | 6     | 8      |
| 6         | 4     | 11    | 9     | 13    | 9     | 11    | 10    | 7     | 12    | 4      |
| 7         | 0     | 3     | 8     | 15    | 13    | 15    | 6     | 9     | 11    | 12     |
| 8         | 0     | 4     | 12    | 10    | 14    | 12    | 7     | 16    | 9     | 6      |
| 9         | 0     | 4     | 3     | 6     | 11    | 15    | 14    | 13    | 14    | 16     |
| 10        | 0     | 0     | 0     | 1     | 6     | 4     | 15    | 15    | 10    | 25     |

| MAX. WIND |       |       |       |       |       |       |       |       |       |        |
|-----------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| 100M S    | DEC.1 | DEC.2 | DEC.3 | DEC.4 | DEC.5 | DEC.6 | DEC.7 | DEC.8 | DEC.9 | DEC.10 |
| 1         | 28    | 16    | 16    | 5     | 7     | 7     | 7     | 2     | 2     | 2      |
| 2         | 19    | 19    | 14    | 13    | 8     | 4     | 7     | 3     | 2     | 1      |
| 3         | 13    | 12    | 9     | 11    | 16    | 7     | 6     | 8     | 6     | 2      |
| 4         | 7     | 13    | 9     | 12    | 12    | 14    | 4     | 10    | 3     | 4      |
| 5         | 7     | 16    | 12    | 9     | 11    | 7     | 4     | 6     | 9     | 9      |
| 6         | 8     | 5     | 9     | 13    | 8     | 10    | 16    | 13    | 7     | 1      |
| 7         | 6     | 7     | 8     | 11    | 8     | 11    | 8     | 11    | 7     | 13     |
| 8         | 0     | 2     | 7     | 4     | 6     | 17    | 13    | 10    | 11    | 8      |
| 9         | 2     | 4     | 3     | 8     | 9     | 6     | 4     | 14    | 18    | 21     |
| 10        | 8     | 0     | 3     | 4     | 3     | 7     | 14    | 7     | 25    | 27     |

| MAX. WIND |       |       |       |       |       |       |       |       |       |        |
|-----------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| 100M S    | DEC.1 | DEC.2 | DEC.3 | DEC.4 | DEC.5 | DEC.6 | DEC.7 | DEC.8 | DEC.9 | DEC.10 |
| 1         | 18    | 23    | 14    | 4     | 8     | 3     | 2     | 1     | 1     | 0      |
| 2         | 23    | 20    | 16    | 11    | 4     | 6     | 4     | 1     | 0     | 0      |
| 3         | 13    | 15    | 16    | 10    | 11    | 9     | 6     | 5     | 4     | 1      |
| 4         | 9     | 12    | 11    | 12    | 16    | 12    | 4     | 5     | 2     | 2      |
| 5         | 6     | 14    | 10    | 9     | 11    | 14    | 9     | 8     | 7     | 6      |
| 6         | 1     | 2     | 4     | 15    | 9     | 13    | 16    | 5     | 7     | 11     |
| 7         | 0     | 3     | 5     | 13    | 12    | 13    | 15    | 15    | 10    | 6      |
| 8         | 0     | 1     | 10    | 10    | 12    | 15    | 5     | 13    | 13    | 11     |
| 9         | 0     | 2     | 3     | 5     | 4     | 7     | 13    | 21    | 24    | 13     |
| 10        | 0     | 0     | 0     | 3     | 3     | 2     | 6     | 10    | 22    | 35     |

| MAX. WIND |       |       |       |       |       |       |       |       |       |        |
|-----------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| 100M S    | DEC.1 | DEC.2 | DEC.3 | DEC.4 | DEC.5 | DEC.6 | DEC.7 | DEC.8 | DEC.9 | DEC.10 |
| 1         | 14    | 26    | 9     | 5     | 4     | 5     | 2     | 2     | 1     | 1      |
| 2         | 24    | 14    | 14    | 7     | 5     | 7     | 4     | 3     | 3     | 4      |
| 3         | 12    | 13    | 17    | 9     | 14    | 3     | 6     | 8     | 3     | 5      |
| 4         | 9     | 8     | 11    | 12    | 12    | 11    | 16    | 5     | 9     | 5      |
| 5         | 9     | 11    | 7     | 10    | 11    | 7     | 11    | 11    | 5     | 8      |
| 6         | 2     | 7     | 11    | 14    | 9     | 11    | 6     | 13    | 9     | 4      |
| 7         | 0     | 3     | 6     | 13    | 12    | 13    | 9     | 13    | 10    | 10     |
| 8         | 0     | 3     | 13    | 13    | 13    | 12    | 10    | 12    | 11    | 3      |
| 9         | 0     | 2     | 7     | 8     | 10    | 17    | 12    | 14    | 14    | 14     |
| 10        | 0     | 0     | 8     | 4     | 2     | 4     | 11    | 15    | 22    | 32     |

| MAX. WIND |       |       |       |       |       |       |       |       |       |        |
|-----------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| 100M S    | DEC.1 | DEC.2 | DEC.3 | DEC.4 | DEC.5 | DEC.6 | DEC.7 | DEC.8 | DEC.9 | DEC.10 |
| 1         | 23    | 19    | 13    | 11    | 11    | 8     | 3     | 1     | 1     | 0      |
| 2         | 15    | 16    | 17    | 10    | 9     | 16    | 3     | 6     | 3     | 1      |
| 3         | 12    | 14    | 6     | 15    | 9     | 4     | 9     | 5     | 7     | 7      |
| 4         | 10    | 7     | 11    | 16    | 12    | 10    | 9     | 6     | 9     | 6      |
| 5         | 8     | 6     | 15    | 14    | 7     | 8     | 4     | 10    | 7     | 8      |
| 6         | 11    | 8     | 9     | 7     | 8     | 12    | 10    | 10    | 7     | 6      |
| 7         | 4     | 6     | 8     | 4     | 8     | 9     | 10    | 9     | 10    | 7      |
| 8         | 4     | 2     | 3     | 14    | 11    | 9     | 8     | 14    | 17    | 8      |
| 9         | 3     | 6     | 5     | 1     | 6     | 8     | 15    | 16    | 16    | 14     |
| 10        | 0     | 2     | 3     | 3     | 9     | 7     | 9     | 9     | 15    | 33     |

| MAX. WIND |       |       |       |       |       |       |       |       |       |        |
|-----------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| 100M S    | DEC.1 | DEC.2 | DEC.3 | DEC.4 | DEC.5 | DEC.6 | DEC.7 | DEC.8 | DEC.9 | DEC.10 |
| 1         | 26    | 25    | 15    | 4     | 3     | 8     | 8     | 8     | 0     | 8      |
| 2         | 26    | 26    | 20    | 7     | 3     | 5     | 2     | 4     | 3     | 0      |
| 3         | 12    | 20    | 23    | 13    | 9     | 5     | 3     | 2     | 3     | 0      |
| 4         | 2     | 10    | 13    | 23    | 17    | 14    | 8     | 2     | 1     | 0      |
| 5         | 2     | 6     | 13    | 18    | 11    | 12    | 12    | 14    | 5     | 1      |
| 6         | 0     | 1     | 4     | 11    | 17    | 10    | 13    | 10    | 8     | 2      |
| 7         | 0     | 0     | 2     | 6     | 19    | 10    | 10    | 19    | 6     | 2      |
| 8         | 0     | 0     | 0     | 7     | 9     | 13    | 10    | 14    | 16    | 13     |
| 9         | 0     | 0     | 0     | 1     | 4     | 11    | 11    | 17    | 21    | 25     |
| 10        | 0     | 0     | 0     | 0     | 1     | 2     | 5     | 10    | 27    | 47     |

| MAX. WIND |       |       |       |       |       |       |       |       |       |        |
|-----------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| 100M S    | DEC.1 | DEC.2 | DEC.3 | DEC.4 | DEC.5 | DEC.6 | DEC.7 | DEC.8 | DEC.9 | DEC.10 |
| 1         | 1     | 6     | 14    | 21    | 17    | 5     | 14    | 5     | 6     | 1      |
| 2         | 2     | 10    | 11    | 9     | 17    | 15    | 7     | 16    | 4     | 1      |
| 3         | 1     | 15    | 14    | 14    | 9     | 9     | 11    | 8     | 6     | 3      |
| 4         | 1     | 13    | 11    | 11    | 16    | 16    | 4     | 11    | 5     | 0      |
| 5         | 6     | 9     | 6     | 14    | 11    | 14    | 12    | 10    | 7     | 5      |
| 6         | 15    | 7     | 8     | 8     | 5     | 13    | 9     | 10    | 8     | 9      |
| 7         | 17    | 15    | 7     | 5     | 4     | 4     | 8     | 7     | 20    | 3      |
| 8         | 16    | 7     | 11    | 2     | 6     | 7     | 7     | 14    | 10    | 14     |
| 9         | 17    | 5     | 5     | 4     | 5     | 9     | 8     | 7     | 14    | 16     |
| 10        | 16    | 3     | 3     | 6     | 6     | 4     | 5     | 6     | 11    | 30     |



# APPENDIX II (Cont.)

|  |  |  |  |  |  |  |  |  |  |  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|--|--|--|--|--|--|--|--|--|--|--|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  |  |  |  |  |  |  |  |  |  |  | <div> <div>+100M S</div> <div>-100M S DEC. DEC.1 DEC.2 DEC.3 DEC.4 DEC.5 DEC.6 DEC.7 DEC.8 DEC.9 DEC.10</div> <div>1 16 21 10 7 7 7 3 2 2 0</div> <div>2 15 23 12 14 9 7 2 2 1 5</div> <div>3 8 13 14 17 14 5 8 8 1 2</div> <div>4 7 11 10 9 7 16 8 11 8 3</div> <div>5 6 6 14 9 15 11 6 12 8 1</div> <div>6 3 6 10 11 7 12 13 9 14 5</div> <div>7 5 0 7 7 10 10 12 13 18 0</div> <div>8 5 3 4 7 10 15 11 7 10 10</div> <div>9 2 4 7 7 5 8 10 10 14 11</div> <div>10 3 3 2 2 6 4 9 14 14 37</div> </div>    |
|  |  |  |  |  |  |  |  |  |  |  | <div> <div>+100M S</div> <div>-100M S DEC. DEC.1 DEC.2 DEC.3 DEC.4 DEC.5 DEC.6 DEC.7 DEC.8 DEC.9 DEC.10</div> <div>1 24 20 14 6 11 7 6 4 0 0</div> <div>2 17 9 9 15 15 9 5 7 1 1</div> <div>3 6 13 8 12 11 11 11 9 6 1</div> <div>4 3 13 10 9 15 8 8 0 0 7</div> <div>5 10 9 7 11 5 11 14 7 10 2</div> <div>6 7 6 9 9 10 9 12 11 11 4</div> <div>7 4 6 8 4 13 5 7 10 14 14</div> <div>8 8 8 8 5 5 5 14 13 10 12</div> <div>9 8 3 9 13 2 7 7 13 9 14</div> <div>10 3 3 8 6 3 14 10 10 14 19</div> </div>     |
|  |  |  |  |  |  |  |  |  |  |  | <div> <div>+100M S</div> <div>-100M S DEC. DEC.1 DEC.2 DEC.3 DEC.4 DEC.5 DEC.6 DEC.7 DEC.8 DEC.9 DEC.10</div> <div>1 16 23 7 3 2 1 0 0 0 0</div> <div>2 19 25 12 10 9 4 0 1 0 0</div> <div>3 8 15 15 17 15 14 6 4 0 0</div> <div>4 2 11 13 12 14 10 8 9 3 0</div> <div>5 1 5 15 10 12 14 16 11 5 1</div> <div>6 1 4 8 10 14 11 14 14 11 3</div> <div>7 1 1 3 10 6 9 16 21 13 10</div> <div>8 0 7 5 8 9 16 12 12 20 9</div> <div>9 1 0 1 6 5 10 11 7 19 30</div> <div>10 1 1 1 4 6 3 7 11 19 37</div> </div> |
|  |  |  |  |  |  |  |  |  |  |  | <div> <div>+100M S</div> <div>-100M S DEC. DEC.1 DEC.2 DEC.3 DEC.4 DEC.5 DEC.6 DEC.7 DEC.8 DEC.9 DEC.10</div> <div>1 17 24 11 9 7 0 1 1 0 0</div> <div>2 11 15 20 13 8 11 7 3 2 0</div> <div>3 16 8 11 9 9 7 12 13 3 2</div> <div>4 8 8 11 7 15 9 13 9 6 4</div> <div>5 3 8 2 17 11 12 10 12 6 10</div> <div>6 3 8 11 7 6 13 9 6 17 10</div> <div>7 5 5 5 6 9 11 4 14 12 19</div> <div>8 3 5 7 8 8 9 15 11 12 12</div> <div>9 1 5 6 8 11 11 13 7 11 17</div> <div>10 3 4 6 6 6 8 6 14 21 16</div> </div>    |
|  |  |  |  |  |  |  |  |  |  |  | <div> <div>+100M S</div> <div>-100M S DEC. DEC.1 DEC.2 DEC.3 DEC.4 DEC.5 DEC.6 DEC.7 DEC.8 DEC.9 DEC.10</div> <div>1 3 15 19 17 13 6 7 7 3 0</div> <div>2 9 11 10 11 11 13 13 7 5 0</div> <div>3 6 9 8 9 11 12 9 13 8 7</div> <div>4 5 12 9 9 10 10 10 8 10 7</div> <div>5 9 11 7 13 7 9 11 9 7 7</div> <div>6 10 8 12 7 9 9 7 8 14 6</div> <div>7 9 2 8 6 6 13 3 17 9 17</div> <div>8 16 8 5 6 6 10 8 3 14 14</div> <div>9 14 5 5 7 7 7 11 11 7 16</div> <div>10 9 9 7 5 10 3 11 7 13 16</div> </div>      |

# APPENDIX II (Cont.)

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>+1000 S DEC.</b>    DEC.1 DEC.2 DEC.3 DEC.4 DEC.5 DEC.6 DEC.7 DEC.8 DEC.9 DEC.10</p> <p>1    27   22   13   6   7   5   3   3   2   2</p> <p>2    22   16   14   9   7   9   9   3   0   1</p> <p>3    18   13   12   12   11   14   9   3   2   4</p> <p>4    11   4   18   9   14   7   11   14   5   5</p> <p>5    6   14   14   11   11   8   3   9   11   3</p> <p>6    4   18   6   12   9   8   11   12   8   8</p> <p>7    4   6   3   8   8   8   12   15   7   19</p> <p>8    1   2   9   18   8   12   17   11   11   9</p> <p>9    3   2   2   8   9   18   8   11   19   16</p> <p>10   2   1   5   5   6   9   7   9   25   21</p>                       | <p><b>-1000 S</b></p> <p><b>-1000 S DEC.</b>    DEC.1 DEC.2 DEC.3 DEC.4 DEC.5 DEC.6 DEC.7 DEC.8 DEC.9 DEC.10</p> <p>1    12   18   14   11   7   6   2   0   0   0</p> <p>2    22   18   11   12   14   4   5   3   1   0</p> <p>3    18   13   14   18   11   9   18   3   2   0</p> <p>4    5   13   9   9   11   19   8   18   5   1</p> <p>5    18   13   11   9   12   8   8   18   9   0</p> <p>6    3   6   11   9   9   12   11   11   11   7</p> <p>7    4   3   6   6   11   18   13   16   18   11</p> <p>8    1   5   6   9   4   11   12   16   12   14</p> <p>9    2   2   2   3   5   8   13   13   21   21</p> <p>10   1   1   6   4   6   3   8   8   19   34</p> |
| <p><b>+1000 S</b></p> <p><b>+1000 S DEC.</b>    DEC.1 DEC.2 DEC.3 DEC.4 DEC.5 DEC.6 DEC.7 DEC.8 DEC.9 DEC.10</p> <p>1    33   22   11   3   5   2   5   4   3   7</p> <p>2    25   28   9   9   8   8   4   1   4   7</p> <p>3    18   12   16   16   9   18   5   5   5   2</p> <p>4    8   13   8   11   16   8   9   5   7   3</p> <p>5    7   9   13   8   13   18   8   13   6   3</p> <p>6    3   3   16   8   18   15   8   9   12   6</p> <p>7    2   4   5   18   7   8   14   9   15   16</p> <p>8    1   5   5   18   18   13   11   16   8   11</p> <p>9    1   8   5   9   8   18   16   11   8   22</p> <p>10   0   2   2   6   4   6   18   17   28   23</p>  | <p><b>-1000 S</b></p> <p><b>-1000 S DEC.</b>    DEC.1 DEC.2 DEC.3 DEC.4 DEC.5 DEC.6 DEC.7 DEC.8 DEC.9 DEC.10</p> <p>1    43   25   14   6   2   8   8   0   0   0</p> <p>2    28   23   24   7   18   5   8   1   0   0</p> <p>3    8   15   15   22   16   8   6   8   8   7</p> <p>4    5   9   16   13   16   14   18   7   8   7</p> <p>5    9   9   5   18   18   16   13   9   2   7</p> <p>6    8   5   6   9   11   15   17   16   15   0</p> <p>7    4   3   5   5   6   12   14   15   16   9</p> <p>8    2   1   2   3   18   12   12   17   28   11</p> <p>9    0   8   1   3   5   7   11   14   22   27</p> <p>10   8   8   2   3   4   3   7   11   17   43</p>     |
| <p><b>+1000 S</b></p> <p><b>+1000 S DEC.</b>    DEC.1 DEC.2 DEC.3 DEC.4 DEC.5 DEC.6 DEC.7 DEC.8 DEC.9 DEC.10</p> <p>1    32   19   9   6   7   6   3   5   2   1</p> <p>2    15   17   18   17   16   3   6   4   1   1</p> <p>3    18   15   17   9   2   7   7   7   7   7</p> <p>4    18   7   14   12   5   9   18   7   8   7</p> <p>5    18   14   7   13   8   12   9   5   6   6</p> <p>6    4   5   18   6   13   18   15   11   18   6</p> <p>7    4   4   8   5   8   18   7   17   13   13</p> <p>8    1   3   7   8   17   15   10   9   4   13</p> <p>9    2   3   4   7   6   6   18   11   18   21</p> <p>10   2   3   4   6   5   7   13   14   16   28</p> | <p><b>-1000 S</b></p> <p><b>-1000 S DEC.</b>    DEC.1 DEC.2 DEC.3 DEC.4 DEC.5 DEC.6 DEC.7 DEC.8 DEC.9 DEC.10</p> <p>1    5   17   15   16   17   9   3   4   3   1</p> <p>2    5   17   13   6   12   14   12   6   2   3</p> <p>3    11   4   18   15   9   13   12   7   4   3</p> <p>4    13   7   6   8   7   11   9   14   11   4</p> <p>5    9   12   9   15   5   3   15   9   7   7</p> <p>6    9   18   7   8   13   7   8   8   14   8</p> <p>7    7   4   9   6   11   9   8   13   8   15</p> <p>8    18   6   9   5   6   6   6   12   15   13</p> <p>9    11   7   5   5   6   8   5   18   14   19</p> <p>10   11   6   7   8   4   18   18   5   12   17</p>       |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <p><b>+1000 S</b></p> <p><b>+1000 S DEC.</b>    DEC.1 DEC.2 DEC.3 DEC.4 DEC.5 DEC.6 DEC.7 DEC.8 DEC.9 DEC.10</p> <p>1    1   17   16   24   17   2   3   7   3   9</p> <p>2    4   24   14   8   15   9   18   7   2   7</p> <p>3    6   6   8   7   13   18   14   12   3   3</p> <p>4    18   18   18   17   6   14   18   12   8   2</p> <p>5    19   5   18   6   11   5   7   0   9   9</p> <p>6    13   7   8   5   4   11   14   11   9   8</p> <p>7    12   7   6   6   8   6   12   9   11   15</p> <p>8    11   7   7   11   3   8   5   0   14   14</p> <p>9    9   9   3   7   4   9   9   9   15   16</p> <p>10   7   2   6   2   9   7   6   11   18   24</p>        |

# APPENDIX II (Cont.)

|  |  |  |  |  |  |  |  |  |  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|--|--|--|--|--|--|--|--|--|--|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  |  |  |  |  |  |  |  |  |  | <p><b>+10000 S</b><br/> <b>-10000 S DEC. DEC.1 DEC.2 DEC.3 DEC.4 DEC.5 DEC.6 DEC.7 DEC.8 DEC.9 DEC.10</b></p> <p>1 26 18 18 9 7 4 5 3 8 9</p> <p>2 16 19 12 12 12 5 8 5 1 8</p> <p>3 13 18 4 25 21 15 5 4 2 1</p> <p>4 6 12 10 9 11 10 12 12 4 4</p> <p>5 5 10 14 7 12 10 11 12 6 3</p> <p>6 6 10 14 7 7 6 12 12 11 5</p> <p>7 5 6 6 10 8 9 15 7 17 7</p> <p>8 6 1 2 6 6 10 8 12 18 15</p> <p>9 3 1 3 6 5 10 10 10 17 25</p> <p>10 4 3 7 9 1 5 4 13 14 30</p>    |
|  |  |  |  |  |  |  |  |  |  | <p><b>+10000 S</b><br/> <b>-10000 S DEC. DEC.1 DEC.2 DEC.3 DEC.4 DEC.5 DEC.6 DEC.7 DEC.8 DEC.9 DEC.10</b></p> <p>1 56 17 8 4 2 3 8 8 8 8</p> <p>2 28 25 15 5 6 5 4 8 1 1</p> <p>3 4 25 12 12 14 6 3 4 2 1</p> <p>4 1 14 16 20 14 15 6 2 2 8</p> <p>5 1 6 19 13 13 10 13 7 5 1</p> <p>6 8 1 8 19 23 12 10 7 7 3</p> <p>7 8 8 4 14 11 12 10 19 7 5</p> <p>8 8 8 1 3 6 19 18 20 17 6</p> <p>9 8 8 8 8 1 7 16 21 25 20</p> <p>10 8 8 8 8 8 1 2 10 24 53</p>          |
|  |  |  |  |  |  |  |  |  |  | <p><b>+10000 S</b><br/> <b>-10000 S DEC. DEC.1 DEC.2 DEC.3 DEC.4 DEC.5 DEC.6 DEC.7 DEC.8 DEC.9 DEC.10</b></p> <p>1 55 24 11 8 8 8 8 8 8 8</p> <p>2 21 26 15 16 8 4 8 8 8 8</p> <p>3 6 11 24 18 14 8 3 2 8 1</p> <p>4 3 9 13 11 17 13 13 9 1 1</p> <p>5 1 11 9 21 14 17 9 3 3 2</p> <p>6 8 5 6 9 17 16 20 18 5 2</p> <p>7 1 3 6 11 11 13 15 14 16 8</p> <p>8 8 1 1 2 8 11 13 20 16 12</p> <p>9 8 8 4 8 8 6 10 15 24 31</p> <p>10 8 8 1 2 2 1 2 7 11 25 41</p>     |
|  |  |  |  |  |  |  |  |  |  | <p><b>+10000 S</b><br/> <b>-10000 S DEC. DEC.1 DEC.2 DEC.3 DEC.4 DEC.5 DEC.6 DEC.7 DEC.8 DEC.9 DEC.10</b></p> <p>1 3 10 21 17 13 7 5 7 1 8</p> <p>2 3 11 14 16 9 9 9 10 8 1</p> <p>3 10 14 12 7 10 15 4 9 6 4</p> <p>4 8 8 8 6 10 13 14 11 5 7</p> <p>5 13 8 7 9 7 10 16 6 3 4</p> <p>6 8 9 8 9 12 6 7 10 6 15</p> <p>7 15 10 3 4 12 7 16 5 11 7</p> <p>8 13 4 9 7 9 8 6 11 15 7</p> <p>9 9 6 6 7 3 8 5 12 15 21</p> <p>10 8 4 2 8 5 7 8 12 15 27</p>            |
|  |  |  |  |  |  |  |  |  |  | <p><b>+10000 S</b><br/> <b>-10000 S DEC. DEC.1 DEC.2 DEC.3 DEC.4 DEC.5 DEC.6 DEC.7 DEC.8 DEC.9 DEC.10</b></p> <p>1 29 12 9 5 11 7 8 4 1 1</p> <p>2 12 15 8 12 11 2 4 6 4 3</p> <p>3 14 12 12 11 9 6 6 6 10 2</p> <p>4 8 10 10 14 9 9 9 6 6 3</p> <p>5 3 9 14 9 14 14 7 7 9 6</p> <p>6 10 7 10 8 8 14 8 10 6 9</p> <p>7 8 5 5 7 16 13 13 12 7 9</p> <p>8 2 1 11 13 3 11 10 7 13 13</p> <p>9 2 5 4 6 7 7 8 19 15 17</p> <p>10 8 4 4 5 2 5 13 13 19 27</p>          |
|  |  |  |  |  |  |  |  |  |  | <p><b>+10000 S</b><br/> <b>-10000 S DEC. DEC.1 DEC.2 DEC.3 DEC.4 DEC.5 DEC.6 DEC.7 DEC.8 DEC.9 DEC.10</b></p> <p>1 10 16 20 17 11 7 5 5 8 1</p> <p>2 9 13 11 11 13 10 13 1 6 3</p> <p>3 9 16 4 10 12 14 8 15 1 1</p> <p>4 7 7 11 13 11 12 12 8 5 4</p> <p>5 17 5 9 8 7 7 10 11 12 3</p> <p>6 7 6 7 11 11 13 8 10 11 8</p> <p>7 12 12 7 5 1 5 10 8 19 15</p> <p>8 4 7 10 5 14 5 14 12 12 11</p> <p>9 14 5 6 2 5 7 7 11 14 10</p> <p>10 3 2 5 8 7 10 5 9 14 27</p> |

# APPENDIX II (Cont.)

| -1400M S |       |       |       |       |       |       |       |       |       |        |
|----------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| -1400M S | DEC.1 | DEC.2 | DEC.3 | DEC.4 | DEC.5 | DEC.6 | DEC.7 | DEC.8 | DEC.9 | DEC.10 |
| 1        | 16    | 18    | 9     | 5     | 12    | 4     | 5     | 5     | 2     |        |
| 2        | 21    | 15    | 11    | 10    | 11    | 7     | 7     | 4     | 3     | 1      |
| 3        | 17    | 5     | 10    | 13    | 3     | 11    | 6     | 7     | 6     | 4      |
| 4        | 9     | 11    | 16    | 10    | 4     | 7     | 5     | 7     | 10    | 7      |
| 5        | 8     | 12    | 14    | 6     | 11    | 5     | 13    | 10    | 4     | 2      |
| 6        | 5     | 9     | 15    | 9     | 7     | 10    | 2     | 6     | 9     | 8      |
| 7        | 3     | 8     | 5     | 10    | 11    | 12    | 12    | 8     | 8     | 6      |
| 8        | 1     | 6     | 9     | 9     | 11    | 11    | 5     | 9     | 14    | 9      |
| 9        | 8     | 8     | 1     | 9     | 7     | 12    | 14    | 13    | 11    | 10     |
| 10       | 0     | 3     | 8     | 3     | 2     | 3     | 11    | 10    | 14    | 12     |
| -1400M S |       |       |       |       |       |       |       |       |       |        |
| -1400M S | DEC.1 | DEC.2 | DEC.3 | DEC.4 | DEC.5 | DEC.6 | DEC.7 | DEC.8 | DEC.9 | DEC.10 |
| 1        | 43    | 26    | 11    | 5     | 4     | 2     | 2     | 8     | 1     | 0      |
| 2        | 24    | 27    | 13    | 9     | 6     | 4     | 3     | 2     | 8     | 5      |
| 3        | 12    | 18    | 16    | 18    | 18    | 7     | 3     | 4     | 2     | 7      |
| 4        | 9     | 14    | 12    | 17    | 12    | 10    | 5     | 5     | 2     | 0      |
| 5        | 2     | 7     | 17    | 11    | 11    | 12    | 17    | 6     | 5     | 2      |
| 6        | 2     | 4     | 12    | 16    | 17    | 7     | 7     | 5     | 4     |        |
| 7        | 0     | 0     | 5     | 11    | 17    | 16    | 17    | 16    | 9     | 1      |
| 8        | 0     | 0     | 1     | 6     | 9     | 12    | 15    | 18    | 21    | 4      |
| 9        | 1     | 0     | 8     | 1     | 2     | 9     | 10    | 21    | 20    | 11     |
| 10       | 0     | 0     | 4     | 0     | 8     | 1     | 1     | 10    | 18    | 04     |
| -1400M S |       |       |       |       |       |       |       |       |       |        |
| -1400M S | DEC.1 | DEC.2 | DEC.3 | DEC.4 | DEC.5 | DEC.6 | DEC.7 | DEC.8 | DEC.9 | DEC.10 |
| 1        | 21    | 19    | 8     | 5     | 11    | 7     | 6     | 7     | 3     | 2      |
| 2        | 25    | 15    | 7     | 12    | 9     | 9     | 7     | 5     | 4     | 0      |
| 3        | 14    | 11    | 13    | 12    | 11    | 7     | 7     | 5     | 5     | 3      |
| 4        | 9     | 9     | 11    | 15    | 11    | 8     | 7     | 4     | 9     | 7      |
| 5        | 6     | 13    | 8     | 15    | 12    | 9     | 5     | 5     | 6     | 7      |
| 6        | 0     | 7     | 10    | 5     | 6     | 14    | 10    | 10    | 7     | 12     |
| 7        | 5     | 0     | 7     | 5     | 10    | 14    | 10    | 12    | 9     | 7      |
| 8        | 4     | 4     | 10    | 9     | 6     | 14    | 14    | 10    | 4     | 11     |
| 9        | 0     | 7     | 3     | 7     | 8     | 13    | 15    | 14    | 17    | 17     |
| 10       | 7     | 3     | 3     | 1     | 1     | 14    | 17    | 23    | 27    |        |
| -1400M S |       |       |       |       |       |       |       |       |       |        |
| -1400M S | DEC.1 | DEC.2 | DEC.3 | DEC.4 | DEC.5 | DEC.6 | DEC.7 | DEC.8 | DEC.9 | DEC.10 |
| 1        | 14    | 25    | 17    | 15    | 7     | 7     | 3     | 1     | 2     | 1      |
| 2        | 6     | 9     | 15    | 20    | 11    | 9     | 10    | 6     | 1     | 2      |
| 3        | 2     | 12    | 12    | 4     | 19    | 12    | 9     | 8     | 1     | 1      |
| 4        | 7     | 12    | 11    | 11    | 10    | 11    | 17    | 12    | 2     | 0      |
| 5        | 9     | 17    | 5     | 12    | 9     | 10    | 17    | 14    | 0     | 7      |
| 6        | 6     | 0     | 0     | 5     | 14    | 11    | 4     | 10    | 11    | 1      |
| 7        | 14    | 7     | 9     | 8     | 0     | 11    | 7     | 10    | 6     |        |
| 8        | 7     | 7     | 7     | 5     | 7     | 10    | 11    | 11    | 17    | 15     |
| 9        | 7     | 5     | 9     | 7     | 7     | 3     | 11    | 5     | 10    | 17     |
| 10       | 0     | 7     | 1     | 1     | 1     | 1     | 3     | 10    | 10    | 16     |
| -1400M S |       |       |       |       |       |       |       |       |       |        |
| -1400M S | DEC.1 | DEC.2 | DEC.3 | DEC.4 | DEC.5 | DEC.6 | DEC.7 | DEC.8 | DEC.9 | DEC.10 |
| 1        | 12    | 14    | 10    | 9     | 8     | 7     | 3     | 2     | 4     | 0      |
| 2        | 4     | 10    | 10    | 14    | 4     | 11    | 4     | 7     | 2     | 2      |
| 3        | 4     | 17    | 13    | 14    | 12    | 11    | 7     | 4     | 1     | 7      |
| 4        | 6     | 5     | 2     | 11    | 14    | 4     | 7     | 15    | 9     | 7      |
| 5        | 7     | 11    | 3     | 13    | 12    | 11    | 12    | 9     | 5     | 4      |
| 6        | 3     | 7     | 7     | 11    | 6     | 11    | 12    | 13    | 13    | 3      |
| 7        | 5     | 5     | 7     | 6     | 0     | 11    | 13    | 13    | 9     | 15     |
| 8        | 7     | 7     | 7     | 4     | 2     | 9     | 9     | 17    | 10    | 14     |
| 9        | 0     | 7     | 4     | 6     | 10    | 6     | 14    | 7     | 19    | 10     |
| 10       | 1     | 3     | 5     | 2     | 5     | 3     | 7     | 11    | 17    | 14     |
| -1400M S |       |       |       |       |       |       |       |       |       |        |
| -1400M S | DEC.1 | DEC.2 | DEC.3 | DEC.4 | DEC.5 | DEC.6 | DEC.7 | DEC.8 | DEC.9 | DEC.10 |
| 1        | 44    | 17    | 17    | 4     | 7     | 0     | 1     | 8     | 0     | 0      |
| 2        | 21    | 22    | 12    | 0     | 11    | 4     | 7     | 1     | 1     | 0      |
| 3        | 12    | 12    | 13    | 13    | 5     | 12    | 9     | 0     | 2     | 7      |
| 4        | 0     | 7     | 3     | 15    | 12    | 12    | 16    | 11    | 4     | 7      |
| 5        | 3     | 7     | 12    | 14    | 11    | 11    | 16    | 11    | 3     | 7      |
| 6        | 7     | 7     | 11    | 0     | 14    | 9     | 7     | 14    | 11    | 4      |
| 7        | 0     | 0     | 4     | 11    | 11    | 12    | 12    | 12    | 0     |        |
| 8        | 2     | 4     | 5     | 7     | 6     | 14    | 11    | 7     | 28    | 16     |
| 9        | 2     | 4     | 3     | 3     | 6     | 0     | 11    | 16    | 10    | 17     |
| 10       | 0     | 7     | 5     | 7     | 4     | 5     | 0     | 11    | 19    | 13     |
| -1400M S |       |       |       |       |       |       |       |       |       |        |
| -1400M S | DEC.1 | DEC.2 | DEC.3 | DEC.4 | DEC.5 | DEC.6 | DEC.7 | DEC.8 | DEC.9 | DEC.10 |
| 1        | 2     | 14    | 23    | 10    | 11    | 3     | 4     | 7     | 2     |        |
| 2        | 6     | 11    | 4     | 13    | 12    | 14    | 14    | 7     | 9     | 0      |
| 3        | 10    | 10    | 13    | 8     | 5     | 11    | 9     | 0     | 2     |        |
| 4        | 9     | 0     | 13    | 7     | 5     | 15    | 14    | 11    | 5     | 0      |
| 5        | 8     | 12    | 11    | 6     | 12    | 7     | 11    | 12    | 7     | 4      |
| 6        | 11    | 0     | 5     | 7     | 11    | 8     | 10    | 3     | 14    | 15     |
| 7        | 10    | 11    | 4     | 6     | 9     | 0     | 9     | 18    | 11    | 12     |
| 8        | 13    | 0     | 9     | 5     | 12    | 7     | 6     | 0     | 13    | 0      |
| 9        | 18    | 3     | 5     | 5     | 4     | 11    | 9     | 12    | 0     | 14     |
| 10       | 6     | 0     | 1     | 5     | 6     | 4     | 10    | 11    | 15    | 23     |

# APPENDIX III

NUMBER OF ENTRIES PER DECILE CELL FROM 5 RANDOM SEQUENCES

| RAND<br>SEQ | DECILE:        | At least $n = 1$ |   |   |   |   |   |   |   |   |    | At most: $n = 1$ |   |   |   |   |   |   |   |   |    |
|-------------|----------------|------------------|---|---|---|---|---|---|---|---|----|------------------|---|---|---|---|---|---|---|---|----|
|             |                | 1                | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1                | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 1           | MAX WIND SPEED | 3                | 1 | 1 | 2 | 4 | 4 | 1 | 1 | 4 | 2  | 1                | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1  |
|             | 100m SHEAR POS | 3                | 5 | 1 | 2 | 1 | 2 | 2 | 1 | 4 | 2  | 1                | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1  |
|             | 100m SHEAR NEG | 3                | 1 | 1 | 1 | 2 | 1 | 2 | 5 | 3 | 4  | 1                | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1  |
|             | 1 km SHEAR POS | 3                | 1 | 1 | 2 | 1 | 4 | 4 | 3 | 2 | 2  | 1                | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1  |
|             | 1 km SHEAR NEG | 1                | 1 | 1 | 4 | 5 | 3 | 2 | 3 | 1 | 2  | 1                | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1  |
|             | 400m SHEAR POS | 3                | 2 | 1 | 3 | 1 | 2 | 3 | 3 | 2 | 3  | 0                | 2 | 0 | 1 | 1 | 0 | 1 | 2 | 1 | 2  |
|             | 400m SHEAR NEG | 2                | 1 | 2 | 1 | 0 | 5 | 1 | 2 | 4 | 5  | 0                | 0 | 2 | 1 | 0 | 1 | 1 | 1 | 1 | 2  |
|             | 3 km SHEAR POS | 2                | 4 | 1 | 4 | 4 | 1 | 1 | 2 | 1 | 4  | 0                | 2 | 1 | 2 | 0 | 0 | 0 | 1 | 1 | 2  |
|             | 3 km SHEAR NEG | 2                | 0 | 1 | 4 | 3 | 4 | 3 | 3 | 3 | 0  | 1                | 1 | 0 | 0 | 0 | 0 | 1 | 2 | 2 | 1  |
|             | MAX WIND SPEED | 3                | 3 | 2 | 3 | 1 | 1 | 1 | 1 | 1 | 5  | 0                | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1  |
| 2           | 100m SHEAR POS | 4                | 2 | 5 | 1 | 1 | 1 | 2 | 1 | 3 | 1  | 1                | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1  |
|             | 100m SHEAR NEG | 1                | 2 | 3 | 3 | 1 | 2 | 1 | 2 | 5 | 1  | 0                | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1  |
|             | 1 km SHEAR POS | 3                | 1 | 2 | 2 | 3 | 1 | 1 | 4 | 2 | 2  | 1                | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1  |
|             | 1 km SHEAR NEG | 1                | 1 | 3 | 4 | 3 | 2 | 1 | 2 | 1 | 3  | 0                | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1  |
|             | 400m SHEAR POS | 4                | 1 | 1 | 2 | 2 | 2 | 4 | 1 | 3 | 1  | 1                | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 2  |
|             | 400m SHEAR NEG | 1                | 2 | 2 | 3 | 2 | 2 | 3 | 3 | 1 | 2  | 0                | 0 | 0 | 1 | 2 | 0 | 2 | 3 | 0 | 0  |
|             | 3 km SHEAR POS | 3                | 2 | 2 | 0 | 2 | 3 | 2 | 3 | 2 | 2  | 1                | 0 | 0 | 0 | 1 | 0 | 1 | 3 | 1 | 1  |
|             | 3 km SHEAR NEG | 1                | 1 | 3 | 4 | 1 | 3 | 2 | 4 | 0 | 2  | 0                | 0 | 1 | 2 | 0 | 2 | 1 | 2 | 0 | 0  |
|             | MAX WIND SPEED | 1                | 2 | 2 | 2 | 4 | 3 | 1 | 1 | 3 | 2  | 0                | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1  |
|             | 100m SHEAR POS | 1                | 2 | 1 | 2 | 2 | 1 | 4 | 3 | 1 | 4  | 1                | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1  |
| 3           | 100m SHEAR NEG | 2                | 2 | 2 | 4 | 3 | 1 | 3 | 1 | 1 | 2  | 1                | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0  |
|             | 1 km SHEAR POS | 1                | 2 | 1 | 2 | 3 | 4 | 2 | 3 | 1 | 2  | 1                | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1  |
|             | 1 km SHEAR NEG | 1                | 2 | 2 | 2 | 2 | 1 | 2 | 3 | 5 | 1  | 1                | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1  |
|             | 400m SHEAR POS | 2                | 2 | 1 | 2 | 2 | 3 | 2 | 3 | 1 | 3  | 1                | 1 | 1 | 0 | 1 | 2 | 0 | 0 | 1 | 1  |
|             | 400m SHEAR NEG | 3                | 2 | 2 | 2 | 0 | 5 | 3 | 1 | 1 | 2  | 0                | 0 | 0 | 0 | 0 | 3 | 2 | 0 | 1 | 0  |
|             | 3 km SHEAR POS | 1                | 3 | 3 | 2 | 1 | 1 | 6 | 1 | 2 | 1  | 1                | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 2 | 0  |
|             | 3 km SHEAR NEG | 0                | 2 | 3 | 0 | 0 | 4 | 3 | 4 | 3 | 2  | 0                | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 2  |
|             | MAX WIND SPEED | 1                | 3 | 1 | 2 | 3 | 1 | 1 | 5 | 1 | 1  | 1                | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1  |
|             | 100m SHEAR POS | 1                | 1 | 3 | 1 | 4 | 2 | 1 | 2 | 3 | 1  | 1                | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1  |
|             | 100m SHEAR NEG | 1                | 2 | 3 | 2 | 1 | 1 | 1 | 5 | 1 | 2  | 1                | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1  |
| 4           | 1 km SHEAR POS | 2                | 2 | 4 | 1 | 2 | 1 | 3 | 2 | 1 | 1  | 1                | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1  |
|             | 1 km SHEAR NEG | 1                | 2 | 1 | 2 | 3 | 5 | 1 | 1 | 1 | 2  | 1                | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1  |
|             | 400m SHEAR POS | 2                | 2 | 2 | 2 | 3 | 0 | 3 | 0 | 2 | 3  | 1                | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 2  |
|             | 400m SHEAR NEG | 1                | 2 | 2 | 3 | 4 | 0 | 1 | 2 | 3 | 1  | 1                | 0 | 0 | 2 | 2 | 1 | 0 | 0 | 2 | 0  |
|             | 3 km SHEAR POS | 2                | 1 | 3 | 3 | 3 | 3 | 2 | 0 | 1 | 1  | 1                | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1  |
|             | 3 km SHEAR NEG | 4                | 0 | 1 | 3 | 1 | 5 | 3 | 1 | 1 | 0  | 2                | 0 | 0 | 2 | 1 | 1 | 2 | 0 | 0 | 0  |
|             | MAX WIND SPEED | 3                | 1 | 2 | 1 | 2 | 4 | 1 | 2 | 1 | 4  | 0                | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1  |
|             | 100m SHEAR POS | 1                | 6 | 2 | 1 | 1 | 3 | 1 | 2 | 2 | 2  | 1                | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0  |
|             | 100m SHEAR NEG | 4                | 3 | 2 | 1 | 3 | 2 | 1 | 2 | 2 | 1  | 1                | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0  |
|             | 1 km SHEAR POS | 2                | 2 | 2 | 4 | 2 | 2 | 2 | 2 | 1 | 2  | 1                | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1  |
| 5           | 1 km SHEAR NEG | 3                | 1 | 2 | 1 | 5 | 2 | 1 | 1 | 2 | 3  | 0                | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1  |
|             | 400m SHEAR POS | 2                | 2 | 3 | 2 | 4 | 2 | 2 | 1 | 1 | 2  | 1                | 1 | 0 | 2 | 1 | 0 | 1 | 1 | 1 | 0  |
|             | 400m SHEAR NEG | 3                | 2 | 2 | 4 | 1 | 4 | 0 | 2 | 1 | 2  | 1                | 1 | 1 | 0 | 1 | 2 | 0 | 1 | 0 | 1  |
|             | 3 km SHEAR POS | 4                | 1 | 1 | 3 | 2 | 2 | 4 | 1 | 0 | 3  | 1                | 1 | 0 | 0 | 0 | 2 | 2 | 1 | 0 | 1  |
|             | 3 km SHEAR NEG | 4                | 4 | 2 | 3 | 2 | 0 | 3 | 0 | 1 | 2  | 1                | 0 | 2 | 1 | 1 | 0 | 2 | 0 | 1 | 0  |

# APPENDIX III (Cont.)

|      |                | At least $m = 2$ |   |   |   |   |   |   |   |   |    | At most: $m = 2$ |   |   |   |   |   |   |   |   |    |
|------|----------------|------------------|---|---|---|---|---|---|---|---|----|------------------|---|---|---|---|---|---|---|---|----|
| RAND | DECILE:        | 1                | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1                | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| SEQ  |                |                  |   |   |   |   |   |   |   |   |    |                  |   |   |   |   |   |   |   |   |    |
| 1    | MAX WIND SPEED | 6                | 2 | 2 | 2 | 4 | 6 | 3 | 4 | 6 | 2  | 2                | 2 | 1 | 0 | 2 | 2 | 2 | 2 | 2 | 2  |
|      | 100m SHEAR POS | 6                | 6 | 2 | 4 | 2 | 4 | 2 | 4 | 5 | 2  | 2                | 2 | 2 | 2 | 0 | 2 | 1 | 2 | 2 | 2  |
|      | 100m SHEAR NEG | 7                | 3 | 2 | 3 | 3 | 3 | 2 | 6 | 4 | 4  | 2                | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 1  |
|      | 1 km SHEAR POS | 5                | 2 | 3 | 3 | 2 | 6 | 4 | 7 | 2 | 3  | 2                | 1 | 2 | 2 | 1 | 2 | 2 | 2 | 1 | 2  |
|      | 1 km SHEAR NEG | 5                | 3 | 2 | 5 | 5 | 3 | 2 | 6 | 2 | 3  | 2                | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 1 | 2  |
|      | 400m SHEAR POS | 5                | 6 | 1 | 5 | 2 | 3 | 4 | 4 | 3 | 4  | 3                | 1 | 1 | 2 | 4 | 0 | 0 | 2 | 2 | 2  |
|      | 400m SHEAR NEG | 7                | 2 | 2 | 4 | 0 | 5 | 3 | 4 | 5 | 5  | 1                | 3 | 1 | 1 | 1 | 2 | 2 | 0 | 3 | 3  |
|      | 3 km SHEAR POS | 4                | 7 | 1 | 4 | 4 | 3 | 3 | 3 | 2 | 6  | 0                | 6 | 1 | 1 | 2 | 1 | 1 | 2 | 0 | 3  |
|      | 3 km SHEAR NEG | 2                | 4 | 5 | 5 | 4 | 5 | 3 | 3 | 5 | 1  | 2                | 0 | 2 | 0 | 1 | 1 | 4 | 2 | 5 | 0  |
|      | MAX WIND SPEED | 5                | 4 | 6 | 4 | 5 | 2 | 3 | 4 | 2 | 5  | 2                | 2 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 2  |
| 2    | 100m SHEAR POS | 6                | 4 | 6 | 3 | 4 | 2 | 3 | 2 | 5 | 5  | 2                | 2 | 2 | 2 | 1 | 0 | 2 | 2 | 2 | 2  |
|      | 100m SHEAR NEG | 3                | 2 | 7 | 5 | 3 | 7 | 2 | 4 | 5 | 2  | 2                | 0 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2  |
|      | 1 km SHEAR POS | 5                | 3 | 2 | 5 | 5 | 3 | 4 | 6 | 3 | 3  | 2                | 2 | 1 | 2 | 2 | 1 | 1 | 2 | 2 | 2  |
|      | 1 km SHEAR NEG | 3                | 3 | 5 | 6 | 5 | 4 | 4 | 4 | 3 | 3  | 2                | 0 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1  |
|      | 400m SHEAR POS | 6                | 3 | 1 | 5 | 3 | 5 | 7 | 2 | 4 | 4  | 3                | 2 | 0 | 2 | 2 | 1 | 1 | 1 | 3 | 2  |
|      | 400m SHEAR NEG | 1                | 2 | 5 | 6 | 4 | 5 | 7 | 7 | 1 | 2  | 1                | 2 | 1 | 2 | 1 | 1 | 6 | 2 | 1 | 0  |
|      | 3 km SHEAR POS | 4                | 5 | 4 | 2 | 5 | 5 | 4 | 4 | 3 | 3  | 2                | 2 | 1 | 0 | 2 | 1 | 1 | 2 | 4 | 2  |
|      | 3 km SHEAR NEG | 2                | 2 | 4 | 8 | 3 | 5 | 7 | 5 | 1 | 3  | 1                | 0 | 2 | 4 | 0 | 5 | 1 | 3 | 1 | 0  |
|      | MAX WIND SPEED | 2                | 5 | 4 | 3 | 5 | 3 | 2 | 4 | 5 | 3  | 2                | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1  |
|      | 100m SHEAR POS | 2                | 2 | 3 | 3 | 5 | 2 | 5 | 6 | 2 | 6  | 2                | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2  |
| 3    | 100m SHEAR NEG | 5                | 2 | 3 | 5 | 4 | 4 | 4 | 5 | 2 | 2  | 2                | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2  |
|      | 1 km SHEAR POS | 3                | 2 | 3 | 4 | 5 | 5 | 4 | 5 | 3 | 2  | 2                | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2  |
|      | 1 km SHEAR NEG | 2                | 4 | 3 | 4 | 5 | 3 | 2 | 4 | 6 | 2  | 2                | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2  |
|      | 400m SHEAR POS | 2                | 5 | 2 | 4 | 3 | 4 | 5 | 4 | 2 | 4  | 3                | 1 | 1 | 1 | 2 | 3 | 4 | 2 | 1 | 1  |
|      | 400m SHEAR NEG | 4                | 4 | 3 | 3 | 2 | 8 | 3 | 5 | 1 | 3  | 4                | 2 | 0 | 0 | 1 | 3 | 2 | 3 | 1 | 3  |
|      | 3 km SHEAR POS | 2                | 6 | 5 | 3 | 1 | 2 | 7 | 3 | 5 | 2  | 2                | 3 | 3 | 2 | 1 | 1 | 2 | 2 | 1 | 2  |
|      | 3 km SHEAR NEG | 1                | 3 | 4 | 1 | 0 | 9 | 5 | 7 | 4 | 2  | 1                | 1 | 1 | 1 | 1 | 3 | 4 | 3 | 3 | 1  |
|      | MAX WIND SPEED | 3                | 4 | 2 | 4 | 5 | 2 | 3 | 7 | 3 | 2  | 1                | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 1 | 2  |
|      | 100m SHEAR POS | 3                | 2 | 3 | 4 | 5 | 3 | 4 | 5 | 4 | 2  | 1                | 1 | 2 | 1 | 2 | 2 | 1 | 2 | 2 | 2  |
|      | 100m SHEAR NEG | 3                | 3 | 4 | 3 | 2 | 2 | 4 | 7 | 5 | 2  | 0                | 2 | 2 | 2 | 1 | 2 | 1 | 2 | 2 | 2  |
| 4    | 1 km SHEAR POS | 5                | 3 | 5 | 2 | 2 | 4 | 4 | 5 | 3 | 2  | 2                | 2 | 2 | 1 | 2 | 1 | 2 | 2 | 0 | 2  |
|      | 1 km SHEAR NEG | 3                | 2 | 3 | 3 | 4 | 7 | 2 | 6 | 3 | 2  | 0                | 2 | 2 | 0 | 2 | 2 | 2 | 2 | 2 | 2  |
|      | 400m SHEAR POS | 5                | 3 | 2 | 4 | 4 | 0 | 6 | 3 | 2 | 6  | 2                | 2 | 2 | 2 | 1 | 0 | 1 | 1 | 3 | 2  |
|      | 400m SHEAR NEG | 2                | 2 | 3 | 4 | 7 | 2 | 3 | 4 | 7 | 1  | 0                | 2 | 1 | 2 | 3 | 2 | 2 | 2 | 3 | 1  |
|      | 3 km SHEAR POS | 4                | 2 | 4 | 6 | 4 | 5 | 3 | 2 | 4 | 1  | 2                | 1 | 3 | 5 | 0 | 0 | 2 | 0 | 2 | 1  |
|      | 3 km SHEAR NEG | 5                | 4 | 2 | 5 | 3 | 7 | 3 | 1 | 4 | 1  | 1                | 0 | 1 | 4 | 0 | 5 | 2 | 2 | 1 | 0  |
|      | MAX WIND SPEED | 3                | 2 | 2 | 2 | 3 | 6 | 2 | 4 | 4 | 5  | 1                | 2 | 1 | 0 | 2 | 2 | 2 | 2 | 2 | 2  |
|      | 100m SHEAR POS | 2                | 6 | 3 | 3 | 2 | 3 | 2 | 5 | 3 | 4  | 1                | 2 | 2 | 2 | 1 | 2 | 0 | 2 | 2 | 2  |
|      | 100m SHEAR NEG | 4                | 3 | 2 | 2 | 5 | 3 | 2 | 4 | 5 | 2  | 2                | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 1 | 1  |
|      | 1 km SHEAR POS | 3                | 2 | 3 | 6 | 2 | 4 | 2 | 4 | 4 | 3  | 2                | 2 | 1 | 2 | 2 | 1 | 2 | 0 | 2 | 2  |
| 5    | 1 km SHEAR NEG | 3                | 2 | 5 | 2 | 5 | 2 | 3 | 2 | 3 | 6  | 0                | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2  |
|      | 400m SHEAR POS | 3                | 2 | 3 | 4 | 5 | 2 | 2 | 3 | 3 | 5  | 2                | 1 | 2 | 1 | 2 | 1 | 2 | 2 | 2 | 1  |
|      | 400m SHEAR NEG | 4                | 3 | 2 | 6 | 3 | 5 | 0 | 3 | 2 | 5  | 0                | 4 | 1 | 2 | 1 | 4 | 1 | 1 | 1 | 1  |
|      | 3 km SHEAR POS | 4                | 1 | 2 | 4 | 2 | 4 | 4 | 5 | 2 | 5  | 3                | 0 | 1 | 2 | 1 | 2 | 3 | 1 | 1 | 2  |
|      | 3 km SHEAR NEG | 6                | 5 | 3 | 3 | 2 | 1 | 5 | 1 | 4 | 3  | 2                | 2 | 1 | 2 | 1 | 2 | 3 | 0 | 3 | 0  |

# APPENDIX III (Cont.)

| RAND<br>SEQ | DECILE:        | At least $n = 3$ |    |   |   |   |    |   |    |   |    | At most $n = 3$ |   |   |   |   |   |   |   |   |    |
|-------------|----------------|------------------|----|---|---|---|----|---|----|---|----|-----------------|---|---|---|---|---|---|---|---|----|
|             |                | 1                | 2  | 3 | 4 | 5 | 6  | 7 | 8  | 9 | 10 | 1               | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 1           | MAX WIND SPEED | 8                | 3  | 4 | 4 | 5 | 8  | 4 | 5  | 9 | 3  | 3               | 3 | 2 | 3 | 3 | 3 | 1 | 2 | 3 | 3  |
|             | 100m SHEAR POS | 8                | 8  | 4 | 5 | 4 | 4  | 5 | 5  | 5 | 4  | 3               | 3 | 3 | 1 | 3 | 2 | 2 | 3 | 3 | 3  |
|             | 100m SHEAR NEG | 8                | 4  | 3 | 3 | 5 | 5  | 5 | 8  | 5 | 5  | 3               | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3  |
|             | 1 km SHEAR POS | 5                | 4  | 8 | 5 | 3 | 6  | 4 | 10 | 3 | 4  | 3               | 3 | 1 | 3 | 2 | 3 | 3 | 3 | 2 | 3  |
|             | 1 km SHEAR NEG | 6                | 4  | 4 | 8 | 8 | 3  | 3 | 8  | 3 | 5  | 2               | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 3  |
|             | 400m SHEAR POS | 5                | 9  | 3 | 8 | 5 | 3  | 6 | 5  | 4 | 4  | 3               | 4 | 2 | 3 | 3 | 0 | 1 | 2 | 5 | 3  |
|             | 400m SHEAR NEG | 9                | 3  | 2 | 5 | 3 | 7  | 5 | 5  | 6 | 7  | 2               | 3 | 2 | 3 | 2 | 2 | 1 | 2 | 4 | 5  |
|             | 3 km SHEAR POS | 4                | 9  | 3 | 7 | 7 | 3  | 4 | 6  | 2 | 7  | 2               | 5 | 1 | 5 | 3 | 1 | 2 | 2 | 2 | 5  |
|             | 3 km SHEAR NEG | 4                | 4  | 8 | 5 | 4 | 6  | 4 | 7  | 5 | 4  | 2               | 3 | 3 | 3 | 3 | 1 | 2 | 4 | 4 | 1  |
|             | MAX WIND SPEED | 6                | 4  | 8 | 5 | 7 | 3  | 5 | 5  | 3 | 5  | 2               | 3 | 3 | 3 | 3 | 1 | 3 | 3 | 3 | 3  |
| 2           | 100m SHEAR POS | 6                | 5  | 8 | 6 | 4 | 3  | 4 | 4  | 5 | 6  | 3               | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 2  |
|             | 100m SHEAR NEG | 3                | 3  | 9 | 6 | 5 | 8  | 3 | 6  | 5 | 3  | 2               | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3  |
|             | 1 km SHEAR POS | 5                | 5  | 3 | 6 | 8 | 5  | 5 | 7  | 4 | 3  | 3               | 2 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 2  |
|             | 1 km SHEAR NEG | 3                | 6  | 6 | 7 | 5 | 5  | 5 | 5  | 6 | 3  | 2               | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 3 | 3  |
|             | 400m SHEAR POS | 6                | 5  | 4 | 5 | 5 | 7  | 7 | 3  | 5 | 4  | 4               | 2 | 1 | 4 | 2 | 5 | 3 | 1 | 2 | 3  |
|             | 400m SHEAR NEG | 1                | 4  | 5 | 7 | 5 | 7  | 9 | 7  | 2 | 2  | 2               | 3 | 3 | 3 | 2 | 1 | 5 | 6 | 2 | 2  |
|             | 3 km SHEAR POS | 4                | 7  | 6 | 5 | 5 | 5  | 4 | 5  | 5 | 4  | 3               | 2 | 3 | 1 | 3 | 3 | 2 | 3 | 5 | 2  |
|             | 3 km SHEAR NEG | 3                | 3  | 4 | 9 | 3 | 8  | 9 | 5  | 4 | 3  | 0               | 2 | 2 | 5 | 0 | 4 | 5 | 5 | 2 | 2  |
|             | MAX WIND SPEED | 4                | 5  | 5 | 4 | 5 | 5  | 5 | 7  | 5 | 3  | 2               | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3  |
|             | 100m SHEAR POS | 5                | 3  | 4 | 4 | 5 | 4  | 5 | 8  | 5 | 6  | 2               | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 2 | 3  |
| 3           | 100m SHEAR NEG | 7                | 3  | 3 | 6 | 5 | 6  | 7 | 6  | 4 | 3  | 3               | 3 | 3 | 3 | 2 | 1 | 3 | 3 | 3 | 2  |
|             | 1 km SHEAR POS | 6                | 3  | 4 | 6 | 5 | 5  | 5 | 8  | 4 | 4  | 3               | 3 | 2 | 3 | 3 | 3 | 1 | 3 | 2 | 3  |
|             | 1 km SHEAR NEG | 4                | 5  | 5 | 4 | 9 | 3  | 7 | 4  | 6 | 3  | 3               | 2 | 2 | 3 | 3 | 1 | 3 | 3 | 3 | 3  |
|             | 400m SHEAR POS | 4                | 5  | 3 | 7 | 4 | 6  | 6 | 5  | 4 | 6  | 2               | 8 | 2 | 1 | 2 | 3 | 4 | 3 | 1 | 2  |
|             | 400m SHEAR NEG | 5                | 4  | 4 | 4 | 3 | 9  | 4 | 8  | 4 | 4  | 4               | 1 | 3 | 2 | 1 | 5 | 3 | 2 | 2 | 3  |
|             | 3 km SHEAR POS | 4                | 7  | 7 | 6 | 2 | 3  | 8 | 4  | 7 | 2  | 2               | 5 | 3 | 2 | 2 | 2 | 2 | 3 | 3 | 2  |
|             | 3 km SHEAR NEG | 4                | 5  | 7 | 1 | 0 | 12 | 6 | 8  | 4 | 3  | 0               | 4 | 1 | 1 | 2 | 4 | 5 | 5 | 4 | 2  |
|             | MAX WIND SPEED | 4                | 6  | 3 | 5 | 5 | 3  | 5 | 9  | 5 | 4  | 2               | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 1 | 3  |
|             | 100m SHEAR POS | 4                | 3  | 5 | 4 | 5 | 5  | 5 | 6  | 8 | 5  | 2               | 2 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 2  |
|             | 100m SHEAR NEG | 3                | 4  | 5 | 4 | 4 | 3  | 6 | 9  | 7 | 4  | 1               | 3 | 3 | 3 | 3 | 1 | 3 | 3 | 3 | 3  |
| 4           | 1 km SHEAR POS | 6                | 4  | 5 | 7 | 4 | 4  | 6 | 5  | 4 | 4  | 3               | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 0 | 3  |
|             | 1 km SHEAR NEG | 4                | 5  | 5 | 5 | 5 | 9  | 3 | 7  | 4 | 3  | 3               | 2 | 3 | 1 | 3 | 3 | 3 | 3 | 2 | 3  |
|             | 400m SHEAR POS | 6                | 5  | 4 | 6 | 4 | 1  | 8 | 5  | 4 | 7  | 3               | 3 | 3 | 1 | 2 | 2 | 4 | 3 | 4 | 3  |
|             | 400m SHEAR NEG | 4                | 3  | 5 | 6 | 7 | 6  | 5 | 5  | 7 | 2  | 2               | 3 | 1 | 3 | 4 | 5 | 2 | 2 | 4 | 2  |
|             | 3 km SHEAR POS | 6                | 3  | 5 | 7 | 4 | 7  | 7 | 2  | 6 | 3  | 4               | 2 | 2 | 5 | 4 | 2 | 2 | 3 | 3 | 2  |
|             | 3 km SHEAR NEG | 8                | 4  | 2 | 8 | 5 | 9  | 6 | 2  | 5 | 1  | 3               | 1 | 1 | 5 | 2 | 6 | 4 | 1 | 3 | 2  |
|             | MAX WIND SPEED | 3                | 4  | 5 | 4 | 3 | 6  | 4 | 9  | 5 | 5  | 3               | 3 | 1 | 2 | 3 | 3 | 3 | 3 | 3 | 3  |
|             | 100m SHEAR POS | 4                | 7  | 5 | 4 | 3 | 6  | 3 | 6  | 4 | 6  | 3               | 3 | 3 | 2 | 1 | 3 | 3 | 3 | 3 | 3  |
|             | 100m SHEAR NEG | 7                | 5  | 4 | 4 | 5 | 4  | 3 | 6  | 6 | 3  | 3               | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 1  |
|             | 1 km SHEAR POS | 6                | 3  | 5 | 6 | 4 | 5  | 3 | 6  | 4 | 6  | 3               | 3 | 1 | 3 | 3 | 3 | 3 | 3 | 2 | 3  |
| 5           | 1 km SHEAR NEG | 8                | 3  | 5 | 3 | 5 | 4  | 3 | 4  | 4 | 7  | 3               | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 2 | 3  |
|             | 400m SHEAR POS | 5                | 5  | 4 | 7 | 7 | 2  | 3 | 4  | 4 | 7  | 2               | 3 | 2 | 2 | 5 | 2 | 3 | 2 | 2 | 4  |
|             | 400m SHEAR NEG | 7                | 3  | 5 | 8 | 5 | 5  | 1 | 3  | 3 | 7  | 3               | 3 | 2 | 4 | 3 | 4 | 1 | 2 | 2 | 3  |
|             | 3 km SHEAR POS | 6                | 3  | 2 | 5 | 4 | 6  | 4 | 8  | 5 | 5  | 4               | 2 | 2 | 2 | 2 | 2 | 4 | 5 | 1 | 3  |
|             | 3 km SHEAR NEG | 6                | 11 | 4 | 3 | 2 | 2  | 7 | 1  | 7 | 5  | 4               | 3 | 3 | 4 | 2 | 2 | 3 | 1 | 5 | 0  |

# APPENDIX III (Cont.)

|      |                | At least $m = 4$ |    |    |    |    |    |    |    |    |    | At most: $m = 4$ |   |   |   |   |   |   |   |   |    |
|------|----------------|------------------|----|----|----|----|----|----|----|----|----|------------------|---|---|---|---|---|---|---|---|----|
| RAND | DECILE:        | 1                | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 | 1                | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| SEQ  |                |                  |    |    |    |    |    |    |    |    |    |                  |   |   |   |   |   |   |   |   |    |
| 1    | MAX WIND SPEED | 9                | 4  | 5  | 4  | 5  | 8  | 4  | 6  | 17 | 7  | 4                | 4 | 3 | 3 | 4 | 4 | 1 | 3 | 4 | 4  |
|      | 100m SHEAR POS | 9                | 9  | 4  | 6  | 5  | 5  | 7  | 6  | 8  | 4  | 4                | 4 | 4 | 0 | 4 | 4 | 3 | 4 | 4 | 3  |
|      | NEG            | 8                | 6  | 5  | 5  | 5  | 6  | 7  | 9  | 6  | 6  | 4                | 4 | 1 | 4 | 4 | 2 | 3 | 4 | 4 | 4  |
|      | 1 km SHEAR POS | 6                | 5  | 11 | 6  | 4  | 6  | 5  | 11 | 4  | 6  | 4                | 4 | 2 | 4 | 2 | 4 | 4 | 4 | 2 | 4  |
|      | NEG            | 7                | 5  | 5  | 8  | 9  | 5  | 5  | 9  | 4  | 7  | 4                | 3 | 2 | 4 | 4 | 4 | 4 | 4 | 1 | 4  |
|      | 400m SHEAR POS | 6                | 9  | 4  | 10 | 5  | 3  | 9  | 5  | 8  | 4  | 4                | 4 | 3 | 4 | 3 | 0 | 4 | 4 | 5 | 3  |
|      | NEG            | 17               | 3  | 4  | 6  | 5  | 9  | 6  | 6  | 7  | 8  | 4                | 3 | 3 | 2 | 3 | 5 | 2 | 2 | 3 | 7  |
|      | 3 km SHEAR POS | 5                | 9  | 3  | 11 | 8  | 3  | 5  | 7  | 4  | 9  | 3                | 7 | 2 | 6 | 4 | 1 | 1 | 4 | 1 | 5  |
|      | NEG            | 5                | 4  | 10 | 7  | 5  | 7  | 5  | 8  | 7  | 5  | 2                | 3 | 2 | 4 | 4 | 4 | 2 | 7 | 5 | 1  |
|      | MAX WIND SPEED | 6                | 7  | 9  | 6  | 8  | 5  | 6  | 5  | 5  | 6  | 4                | 3 | 4 | 4 | 4 | 3 | 4 | 4 | 4 | 4  |
| 2    | 100m SHEAR POS | 8                | 6  | 10 | 6  | 5  | 5  | 5  | 4  | 7  | 6  | 4                | 4 | 4 | 4 | 4 | 3 | 4 | 3 | 4 | 4  |
|      | NEG            | 5                | 4  | 10 | 9  | 5  | 8  | 4  | 6  | 7  | 4  | 3                | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4  |
|      | 1 km SHEAR POS | 7                | 5  | 5  | 8  | 9  | 6  | 6  | 8  | 4  | 5  | 4                | 4 | 2 | 4 | 4 | 4 | 4 | 4 | 4 | 4  |
|      | NEG            | 5                | 8  | 7  | 8  | 7  | 6  | 5  | 5  | 8  | 4  | 4                | 4 | 4 | 4 | 4 | 4 | 2 | 4 | 4 | 4  |
|      | 400m SHEAR POS | 8                | 6  | 5  | 7  | 5  | 9  | 9  | 3  | 6  | 5  | 4                | 2 | 3 | 4 | 3 | 8 | 4 | 1 | 5 | 4  |
|      | NEG            | 4                | 7  | 7  | 8  | 7  | 8  | 9  | 8  | 3  | 2  | 2                | 4 | 5 | 4 | 4 | 3 | 5 | 8 | 3 | 3  |
|      | 3 km SHEAR POS | 6                | 7  | 8  | 7  | 5  | 7  | 6  | 5  | 7  | 4  | 4                | 3 | 3 | 2 | 5 | 5 | 3 | 5 | 5 | 3  |
|      | NEG            | 4                | 4  | 5  | 10 | 3  | 10 | 10 | 6  | 5  | 6  | 1                | 4 | 2 | 8 | 2 | 3 | 6 | 7 | 2 | 3  |
|      | MAX WIND SPEED | 4                | 6  | 8  | 4  | 7  | 6  | 5  | 7  | 6  | 6  | 3                | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 0  |
|      | 100m SHEAR POS | 6                | 4  | 5  | 6  | 5  | 5  | 7  | 9  | 5  | 7  | 2                | 3 | 2 | 4 | 4 | 4 | 4 | 4 | 4 | 4  |
| 3    | NEG            | 7                | 4  | 5  | 8  | 5  | 7  | 8  | 6  | 4  | 5  | 4                | 2 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 2  |
|      | 1 km SHEAR POS | 6                | 4  | 5  | 7  | 7  | 5  | 5  | 9  | 5  | 6  | 4                | 2 | 4 | 4 | 4 | 4 | 3 | 4 | 3 | 3  |
|      | NEG            | 4                | 7  | 5  | 4  | 11 | 4  | 8  | 4  | 7  | 4  | 3                | 4 | 4 | 4 | 4 | 3 | 4 | 4 | 1 | 1  |
|      | 400m SHEAR POS | 5                | 7  | 3  | 7  | 5  | 6  | 7  | 6  | 7  | 6  | 3                | 4 | 4 | 3 | 2 | 4 | 4 | 4 | 2 | 5  |
|      | NEG            | 7                | 5  | 6  | 5  | 4  | 9  | 5  | 8  | 4  | 6  | 6                | 3 | 3 | 2 | 3 | 5 | 4 | 4 | 3 | 2  |
|      | 3 km SHEAR POS | 4                | 9  | 7  | 7  | 2  | 4  | 8  | 7  | 8  | 3  | 3                | 5 | 5 | 3 | 2 | 4 | 5 | 4 | 3 | 1  |
|      | NEG            | 4                | 6  | 9  | 2  | 8  | 13 | 6  | 10 | 4  | 5  | 2                | 4 | 4 | 2 | 1 | 6 | 4 | 6 | 4 | 2  |
|      | MAX WIND SPEED | 6                | 6  | 4  | 11 | 5  | 4  | 7  | 9  | 5  | 6  | 3                | 4 | 2 | 4 | 4 | 2 | 4 | 4 | 4 | 4  |
|      | 100m SHEAR POS | 6                | 4  | 5  | 7  | 5  | 6  | 5  | 6  | 10 | 8  | 4                | 1 | 4 | 3 | 4 | 4 | 4 | 4 | 4 | 3  |
|      | NEG            | 4                | 5  | 8  | 5  | 5  | 4  | 6  | 9  | 10 | 7  | 3                | 3 | 4 | 4 | 3 | 2 | 4 | 4 | 4 | 4  |
| 4    | 1 km SHEAR POS | 7                | 5  | 7  | 10 | 7  | 4  | 8  | 6  | 6  | 4  | 4                | 4 | 4 | 4 | 4 | 1 | 4 | 4 | 2 | 4  |
|      | NEG            | 4                | 6  | 7  | 6  | 7  | 11 | 5  | 7  | 7  | 4  | 4                | 4 | 4 | 2 | 4 | 4 | 2 | 4 | 4 | 3  |
|      | 400m SHEAR POS | 8                | 6  | 5  | 7  | 5  | 2  | 13 | 5  | 5  | 8  | 6                | 1 | 4 | 4 | 3 | 0 | 6 | 2 | 5 | 4  |
|      | NEG            | 5                | 4  | 5  | 7  | 8  | 9  | 6  | 8  | 7  | 5  | 4                | 3 | 3 | 4 | 5 | 4 | 2 | 3 | 5 | 3  |
|      | 3 km SHEAR POS | 7                | 6  | 7  | 9  | 5  | 8  | 8  | 2  | 8  | 4  | 5                | 3 | 2 | 5 | 4 | 4 | 2 | 1 | 5 | 4  |
|      | NEG            | 8                | 6  | 3  | 10 | 7  | 10 | 9  | 2  | 7  | 2  | 4                | 3 | 1 | 7 | 2 | 7 | 4 | 3 | 3 | 1  |
|      | MAX WIND SPEED | 4                | 7  | 5  | 7  | 4  | 6  | 5  | 11 | 6  | 6  | 3                | 4 | 4 | 2 | 4 | 4 | 3 | 4 | 4 | 4  |
|      | 100m SHEAR POS | 4                | 8  | 9  | 5  | 4  | 8  | 4  | 7  | 5  | 7  | 4                | 4 | 4 | 3 | 4 | 4 | 1 | 4 | 4 | 4  |
|      | NEG            | 10               | 6  | 7  | 7  | 5  | 4  | 4  | 6  | 6  | 5  | 4                | 4 | 4 | 3 | 4 | 4 | 3 | 4 | 4 | 2  |
|      | 1 km SHEAR POS | 7                | 4  | 5  | 9  | 5  | 7  | 5  | 7  | 4  | 7  | 4                | 4 | 2 | 4 | 4 | 3 | 4 | 4 | 3 | 4  |
| 5    | NEG            | 9                | 7  | 8  | 4  | 7  | 4  | 5  | 5  | 4  | 8  | 4                | 4 | 4 | 2 | 4 | 4 | 4 | 3 | 3 | 4  |
|      | 400m SHEAR POS | 6                | 6  | 4  | 8  | 12 | 4  | 5  | 4  | 5  | 7  | 4                | 4 | 4 | 4 | 5 | 2 | 2 | 2 | 4 | 5  |
|      | NEG            | 10               | 4  | 5  | 11 | 7  | 7  | 2  | 4  | 3  | 8  | 3                | 3 | 3 | 6 | 5 | 5 | 1 | 3 | 2 | 5  |
|      | 3 km SHEAR POS | 8                | 3  | 4  | 7  | 5  | 6  | 5  | 12 | 5  | 5  | 4                | 5 | 3 | 3 | 3 | 4 | 5 | 5 | 3 | 3  |
|      | NEG            | 6                | 12 | 5  | 5  | 7  | 3  | 7  | 3  | 8  | 5  | 5                | 5 | 2 | 4 | 2 | 2 | 7 | 3 | 3 | 3  |



# APPENDIX III (Cont.).

|      |                | At least $n = 5$ |    |    |    |    |    |    |    |    |    | At most: $n = 5$ |   |   |   |   |   |    |   |   |    |
|------|----------------|------------------|----|----|----|----|----|----|----|----|----|------------------|---|---|---|---|---|----|---|---|----|
| RAND | DECILE:        | 1                | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 | 1                | 2 | 3 | 4 | 5 | 6 | 7  | 8 | 9 | 10 |
| 1    | SEQ            |                  |    |    |    |    |    |    |    |    |    |                  |   |   |   |   |   |    |   |   |    |
|      | MAX WIND SPEED | 9                | 5  | 7  | 5  | 7  | 10 | 5  | 8  | 11 | 7  | 5                | 3 | 5 | 3 | 5 | 5 | 5  | 5 | 5 | 5  |
|      | 100m SHEAR POS | 11               | 10 | 5  | 6  | 5  | 6  | 7  | 8  | 9  | 6  | 5                | 5 | 5 | 4 | 5 | 5 | 4  | 5 | 5 | 3  |
|      | NEG            | 9                | 7  | 6  | 6  | 7  | 6  | 8  | 10 | 8  | 7  | 5                | 4 | 4 | 5 | 5 | 4 | 4  | 5 | 5 | 5  |
|      | 1 km SHEAR POS | 8                | 6  | 12 | 6  | 5  | 7  | 5  | 12 | 6  | 7  | 5                | 5 | 3 | 4 | 5 | 5 | 5  | 5 | 4 | 5  |
|      | NEG            | 7                | 6  | 5  | 9  | 9  | 7  | 6  | 11 | 5  | 8  | 5                | 5 | 3 | 5 | 5 | 5 | 4  | 5 | 4 | 5  |
|      | 400m SHEAR POS | 9                | 9  | 5  | 12 | 5  | 3  | 10 | 6  | 9  | 5  | 5                | 7 | 2 | 5 | 5 | 3 | 4  | 4 | 5 | 5  |
|      | NEG            | 10               | 4  | 4  | 6  | 7  | 11 | 5  | 7  | 8  | 11 | 6                | 3 | 2 | 5 | 1 | 8 | 5  | 3 | 6 | 7  |
|      | 3 km SHEAR POS | 6                | 10 | 3  | 12 | 10 | 3  | 8  | 9  | 4  | 9  | 5                | 7 | 3 | 6 | 4 | 4 | 3  | 6 | 1 | 7  |
|      | NEG            | 5                | 5  | 12 | 8  | 5  | 7  | 5  | 10 | 11 | 5  | 3                | 2 | 2 | 7 | 5 | 6 | 6  | 7 | 6 | 2  |
| 2    | MAX WIND SPEED | 7                | 8  | 10 | 7  | 9  | 7  | 6  | 6  | 6  | 9  | 5                | 4 | 5 | 5 | 5 | 4 | 5  | 4 | 4 | 5  |
|      | 100m SHEAR POS | 8                | 9  | 11 | 6  | 5  | 6  | 8  | 6  | 9  | 6  | 5                | 5 | 5 | 5 | 2 | 4 | 5  | 5 | 5 | 5  |
|      | NEG            | 5                | 5  | 12 | 9  | 7  | 8  | 7  | 8  | 9  | 5  | 4                | 4 | 5 | 5 | 5 | 5 | 5  | 5 | 5 | 3  |
|      | 1 km SHEAR POS | 7                | 7  | 5  | 9  | 10 | 7  | 8  | 9  | 5  | 8  | 5                | 5 | 5 | 5 | 4 | 5 | 5  | 5 | 2 | 5  |
|      | NEG            | 5                | 8  | 7  | 11 | 9  | 7  | 7  | 5  | 9  | 8  | 5                | 5 | 5 | 5 | 5 | 5 | 2  | 5 | 5 | 4  |
|      | 400m SHEAR POS | 8                | 6  | 7  | 8  | 5  | 11 | 11 | 4  | 6  | 9  | 6                | 4 | 5 | 4 | 3 | 5 | 5  | 3 | 6 | 5  |
|      | NEG            | 5                | 8  | 9  | 9  | 7  | 10 | 10 | 9  | 3  | 6  | 4                | 5 | 4 | 6 | 5 | 6 | 6  | 7 | 0 | 3  |
|      | 3 km SHEAR POS | 6                | 8  | 11 | 7  | 5  | 8  | 9  | 6  | 7  | 7  | 5                | 5 | 5 | 2 | 5 | 7 | 5  | 3 | 6 | 3  |
|      | NEG            | 5                | 5  | 5  | 10 | 3  | 11 | 13 | 9  | 6  | 8  | 2                | 4 | 5 | 8 | 3 | 5 | 6  | 5 | 2 | 6  |
| 3    | MAX WIND SPEED | 7                | 7  | 11 | 6  | 8  | 8  | 6  | 7  | 5  | 6  | 4                | 5 | 5 | 5 | 5 | 5 | 4  | 4 | 5 | 2  |
|      | 100m SHEAR POS | 7                | 8  | 5  | 7  | 5  | 6  | 8  | 10 | 6  | 8  | 4                | 5 | 2 | 5 | 5 | 3 | 5  | 5 | 5 | 5  |
|      | NEG            | 9                | 5  | 5  | 11 | 5  | 7  | 9  | 8  | 6  | 6  | 5                | 2 | 5 | 5 | 4 | 5 | 5  | 5 | 4 | 4  |
|      | 1 km SHEAR POS | 8                | 5  | 5  | 8  | 8  | 7  | 7  | 11 | 6  | 6  | 5                | 3 | 5 | 5 | 5 | 5 | 2  | 5 | 4 | 5  |
|      | NEG            | 5                | 8  | 9  | 6  | 11 | 5  | 11 | 5  | 7  | 5  | 3                | 5 | 5 | 5 | 5 | 4 | 5  | 4 | 5 | 3  |
|      | 400m SHEAR POS | 5                | 9  | 5  | 10 | 5  | 7  | 7  | 8  | 8  | 7  | 4                | 4 | 5 | 5 | 4 | 4 | 5  | 4 | 2 | 7  |
|      | NEG            | 8                | 5  | 7  | 9  | 5  | 10 | 5  | 8  | 5  | 8  | 6                | 6 | 4 | 4 | 1 | 7 | 4  | 5 | 5 | 2  |
|      | 3 km SHEAR POS | 5                | 13 | 8  | 10 | 3  | 4  | 8  | 10 | 8  | 3  | 3                | 9 | 7 | 3 | 2 | 2 | 7  | 4 | 4 | 3  |
|      | NEG            | 5                | 6  | 10 | 4  | 4  | 15 | 7  | 11 | 5  | 5  | 3                | 3 | 5 | 2 | 2 | 8 | 6  | 6 | 4 | 4  |
| 4    | MAX WIND SPEED | 7                | 7  | 7  | 13 | 5  | 5  | 7  | 10 | 6  | 7  | 5                | 5 | 4 | 5 | 5 | 2 | 5  | 5 | 4 | 5  |
|      | 100m SHEAR POS | 11               | 5  | 8  | 7  | 5  | 6  | 7  | 6  | 11 | 8  | 5                | 2 | 5 | 3 | 5 | 5 | 5  | 5 | 5 | 5  |
|      | NEG            | 5                | 6  | 11 | 6  | 5  | 6  | 6  | 10 | 12 | 7  | 4                | 4 | 5 | 4 | 4 | 4 | 5  | 5 | 5 | 5  |
|      | 1 km SHEAR POS | 8                | 7  | 9  | 12 | 8  | 5  | 9  | 6  | 7  | 5  | 5                | 5 | 5 | 5 | 5 | 2 | 5  | 5 | 4 | 4  |
|      | NEG            | 6                | 6  | 8  | 8  | 9  | 12 | 7  | 7  | 7  | 5  | 5                | 5 | 5 | 4 | 4 | 5 | 4  | 5 | 5 | 3  |
|      | 400m SHEAR POS | 9                | 9  | 7  | 8  | 5  | 2  | 14 | 6  | 5  | 9  | 7                | 1 | 5 | 4 | 4 | 1 | 10 | 2 | 5 | 6  |
|      | NEG            | 7                | 6  | 5  | 8  | 10 | 10 | 6  | 10 | 7  | 6  | 6                | 4 | 3 | 6 | 7 | 3 | 2  | 5 | 6 | 3  |
|      | 3 km SHEAR POS | 8                | 8  | 8  | 11 | 5  | 8  | 9  | 3  | 8  | 6  | 6                | 4 | 5 | 7 | 4 | 4 | 3  | 1 | 7 | 4  |
|      | NEG            | 10               | 8  | 4  | 10 | 8  | 12 | 10 | 2  | 9  | 2  | 5                | 4 | 4 | 7 | 7 | 7 | 4  | 3 | 3 | 1  |
| 5    | MAX WIND SPEED | 6                | 7  | 7  | 8  | 5  | 7  | 7  | 12 | 8  | 7  | 3                | 5 | 5 | 3 | 5 | 5 | 4  | 5 | 5 | 5  |
|      | 100m SHEAR POS | 5                | 10 | 9  | 7  | 5  | 10 | 5  | 9  | 7  | 8  | 5                | 5 | 5 | 4 | 5 | 5 | 1  | 5 | 5 | 5  |
|      | NEG            | 10               | 7  | 11 | 7  | 5  | 7  | 5  | 7  | 7  | 8  | 5                | 4 | 5 | 5 | 5 | 5 | 5  | 5 | 3 | 3  |
|      | 1 km SHEAR POS | 9                | 5  | 7  | 10 | 5  | 7  | 6  | 10 | 5  | 10 | 5                | 5 | 3 | 5 | 4 | 5 | 5  | 5 | 3 | 5  |
|      | NEG            | 10               | 9  | 12 | 5  | 9  | 5  | 5  | 5  | 6  | 8  | 5                | 4 | 5 | 5 | 5 | 5 | 5  | 2 | 4 | 5  |
|      | 400m SHEAR POS | 8                | 6  | 5  | 9  | 12 | 5  | 6  | 7  | 7  | 10 | 6                | 4 | 4 | 3 | 7 | 4 | 3  | 4 | 4 | 6  |
|      | NEG            | 11               | 6  | 5  | 12 | 8  | 9  | 4  | 6  | 5  | 8  | 6                | 3 | 2 | 8 | 5 | 6 | 2  | 4 | 3 | 5  |
|      | 3 km SHEAR POS | 8                | 5  | 5  | 8  | 9  | 7  | 5  | 13 | 7  | 7  | 6                | 4 | 3 | 3 | 4 | 4 | 6  | 8 | 3 | 4  |
|      | NEG            | 8                | 15 | 5  | 5  | 8  | 3  | 11 | 4  | 10 | 5  | 7                | 6 | 2 | 5 | 3 | 2 | 8  | 4 | 5 | 3  |

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