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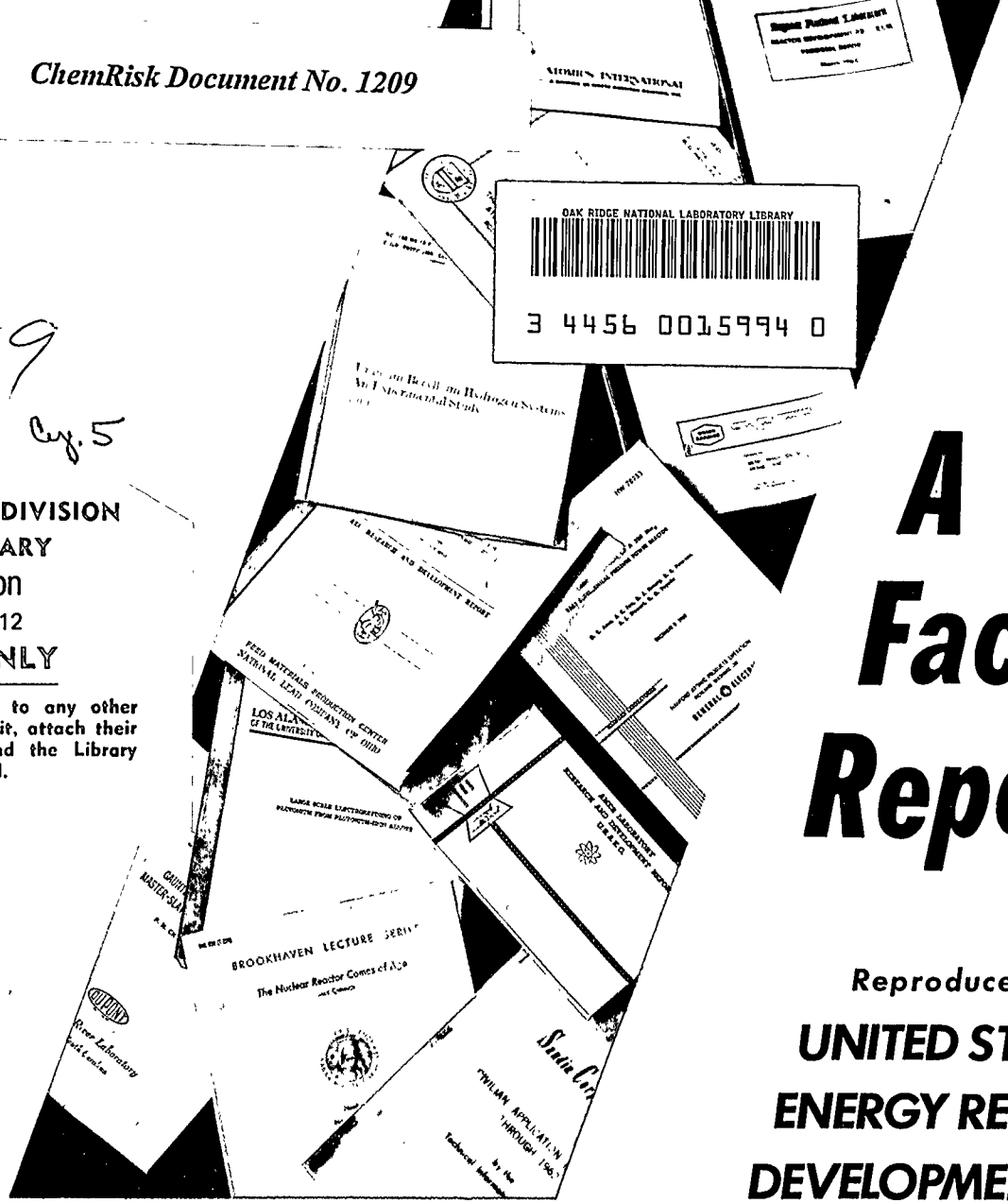

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METEOROLOGY

SUPPLEMENTARY METEOROLOGICAL DATA FOR OAK RIDGE

By
William F. Hilsmeier

March 15, 1963
[DTI Issuance Date]

Weather Bureau Research Station
Oak Ridge, Tennessee

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ORO-1

SUPPLEMENTARY METEOROLOGICAL DATA FOR OAK RIDGE

William F. Hilsmeier
Weather Bureau Research Station, Oak Ridge, Tennessee

In response to requests for meteorological data involving weather parameters that influence construction, cooling and air conditioning designs, and various other activities and interests in the Oak Ridge area, the following charts, graphs, and discussion are presented. An additional motive for providing data supplemental to that contained in ORO-99 [1] arises because early studies of the meteorology of the area were not in some cases as general as one would like. This was mostly due to the short period of sampling, 1 to 4 years, and occasionally due to instrument error as indicated, for example, by the reference in ORO-99 to a spurious increase in inversion frequency in 1951.

The sites for which the data were prepared are shown in Figure 1, and described in Table I. They are:

Town or Townsite - Located at Cheyenne Hall in the vicinity of the AEC building. Installed by the AEC Department of Public Works, it was sometimes called Public Works station.

Y-12 - Located in the Y-12 area; this station is designated in ORO-99 as 018, Y-12 Health Physics.

X-10 - Now designated as ORNL, Oak Ridge National Laboratory. The particular location is that referred to in ORO-99 as 012, X-10 Health Physics Division.

TSF - Tower Shielding Facility.

K-25 - Also known as the Oak Ridge Gaseous Diffusion Plant.

With the exception of the new observation point, TSF, these designations were all used in ORO-99. In this study the sites will be referred to by their short designation, the only possible confusion being in the case of X-10, which is also commonly called ORNL.

TABLE I

Site and Instrumentation (Fall 1962)

Site	Location	Ground Level Ft. MSL	Telemetered Instrumentation					Temp. Grad. Span	Upper Instrument Level, Ft. MSL
			Temp.	Precip.	Wind		Dew Point		
					Vane	Anemometer			
Town	36° 01' N 84° 14' W on the Oak Ridge Turnpike between Tyndale and Tennyson Streets at Cheyenne Hall.	905	TC	WG	16 PC	3 CC	DC	none	955
Y-12	35° 59' N 84° 15' W inside the Y-12 area in Bear Creek Valley in the vicinity of the 9706-2 Bldg. (known as dispensary).	945	TC	WG	16 PC	3 CC	DC	55 ft.	1005
X-10	35° 56' N 84° 19' W atop a 90 foot ridge in the ORNL area, which is in Bethel Valley. This also is the ORNL Water Tower site.	886	TC	WG	16 PC	3 CC	DC	135 ft.	1026
TSF	35° 54' N 84° 18' on Copper Ridge. The instruments are on and in the vicinity of the NE Tower.	1073	TC	—	16 PC	3 CC	DC	310 ft.	1387
K-25	35° 55' N 84° 23' W at the NE corner of Building K-303-7 of the main Gaseous Diffusion Plant.	780	TC	EG	16 PC	3 CC	DC	none	891

Surface temperatures are read at 5 feet above the ground with the exception of TSF which is 4 feet above the ground level. Wind equipment is at the upper level.

TC - Thermocouple, Aspirated
WG - Weighing Raingage
EG - Electronic Raingage

16 PC - 16 Point Contacting Vane
3 CC - 3 Cup Contacting Anemometer
DC - Foxboro Dew Cell

I Temperature

Figures 2 through 25 are sets of probability curves for dry bulb, wet bulb, and dew point temperatures, based on hourly observations. In reading from left to right the probability percentage applies to values equal to or less than the corresponding temperature. In reading from right to left the probability percentages apply to values greater than the corresponding temperature. For example, reading from left to right, X% of the temperatures are equal to or less than temperature, Y° F. Reading the other way, i.e. right to left, X% of the temperatures are greater than temperature, Y° F.

By way of a review, definitions of the three temperatures discussed are:

Dry bulb temperature is the temperature of the air, measured by a conventional thermometer.

Wet bulb temperature gives a measure of the moisture in the air. It is the temperature of evaporation or the temperature to which the air can be cooled by evaporation.

Dew point temperature is that temperature at which saturation of the air is just reached, without a change of pressure; or that temperature at which the saturation vapor pressure is the same as the existing vapor pressure. It is the temperature at which vapor in air will begin to condense.

The dry bulb temperature curves are shown for each month, for the year, and for the summer months, which are considered for our purposes to be the months of May through September, in Figures 2 through 15. These curves are based on 10 years of record, 1949 to 1958, at the X-10 site. The wet bulb and dew point temperature curves, Figures 16 through 20, and 21 through 25, based on 5 years of record from 1956 to 1960, are shown for just the summer months. Both Y-12 and X-10 probabilities were calculated due to the interest in these parameters for the two locations. However, as shown in the Figures 16 through 25, for which X-10 and Y-12 curves are

shown superimposed, data from either are valid for the other. Generally X-10 data would be preferred, due to the greater length of record.

If the curves are assumed to be straight lines, one can find the approximate mean temperature at the 50% line. The standard deviation can be estimated by subtracting the difference in the temperature values at 84% and 50% [2].

II Wind Data

New wind roses are shown here for lapse and inversion conditions by seasons for the X-10, Y-12, and TSF areas, Figures 26-27, 28-29, and 30-31. The K-25 area roses are for all observations, lapse and inversion combined, by seasons, Figure 32. The wind roses are prepared from 5 years of data. As shown in CRO-99 [1], the prevailing directions are NE and SW. The next most common wind is from the west, as best typified by the winter wind rose for X-10 under lapse conditions.

The wind vanes and anemometers which provide the data for the wind roses are at varying locations and elevations as shown on the map of installations in the Oak Ridge area, Figure 1 and Table I. Heights indicated on the map refer to mean sea level (MSL).

III Temperature Gradient Data

In connection with the temperature and wind studies described above, the monthly frequency of temperature gradients during day and night as a function of the mean wind speed for each temperature gradient class, was analyzed, and the results appear in Figures 33 through 44. The data are for the X-10 station, which is located on a 90 foot ridge in the Bethel valley. The temperature gradient is the difference in temperature between measurements at levels 5 feet and 145 feet above the ridge converted to degrees F per 100 feet elevation.

The percentage of inversion conditions of the total hours for the seasons is as follows:

Winter	Spring	Summer	Autumn	Annual
31.8%	35.1%	35.1%	42.5%	35.9%

These values compare rather well with the inversion frequency estimates for this area that were reported in a Monthly Weather Review article by Hosler [3] on inversion frequencies in the United States.[1]

IV Precipitation

Twelve years of precipitation data were analyzed for the Town and X-10 sites. Approximately 9.5 miles separate the two areas in a northeast - southwesterly direction. In the direction of most thunderstorm and frontal movement, from the northwest to the southeast over the Cumberland Mountains, approximately 2.8 miles separate the areas.

Annually, Town averages seven more days with precipitation than X-10, a precipitation day being defined as one with measurable precipitation of .01 inches or more. The difference in precipitation days decreases as the amount of precipitation increases. For example, Town averages only two precipitation days more than X-10 for amounts of .10 or more, and X-10 equals Town in precipitation days with .25 or more inches, cf. Figures 45 and 46. The normal annual precipitation amounts received at the two stations are 54.71 inches for Town, and 51.52 inches for X-10.[2]

---

[1] The inversion frequencies shown above for X-10 agree with the Nashville and Greensboro data better than the average for the Oak Ridge area given in the MWR article.

[2] The normals published in the U. S. Department of Commerce, Weather Bureau, Local Climatological Data, 1962, for Oak Ridge, Tennessee, are derived from 1931-60 data, and are means adjusted to represent observations taken at the present standard locations.

Histograms of the number of consecutive dry days show little variation between the two sites, Figure 47. Town has 1.5 more 1-day dry periods a year than X-10, and X-10 has 1.6 more 3-day dry periods a year than Town. Further breakdown of the data shows that 47% of the wet periods are of 1-day duration. However 49% of the dry periods are of 1 and 2 days duration. Of the dry periods which last a week or more, the highest frequency is in the summer followed closely by fall. The longest dry spells, periods of 20 to 31 days without rain, occur in the fall season. The number of consecutive wet days is more frequently in the 1 to 4-day range, the highest frequencies of four consecutive days with precipitation occurring in the winter and spring, Figure 48. The most consecutive days with rain occur in the spring and summer, with the frequency for summer being the higher. In both seasons this could be attributed to showery type precipitation, summer being the most likely season for showers. There is a tendency to refer to precipitation in the Oak Ridge area as rain, since most of it is in the form of rain. However snow does occur, occasionally of sufficient quantity to hinder or even suspend traffic and outdoor activities. During the winter of 1959-1960 a total of 41.4 inches of snow fell, of which 21.0 inches came in March. It is estimated that this unusually large seasonal amount of snowfall should occur with a frequency of approximately once in 100 years. Notice, however, that it occurred within 10 years of the 2-year period of the meteorological survey, ORO-99, during which "no snow of any significance occurred", emphasizing the extreme variability of snowfall in this area. The average snowfall for 13 winters, 1948-1949 through 1960-1961, is 6.9 inches.

V Summary

Perhaps the precipitation situation can best be described for the Oak Ridge area by noting precipitation occurs on the average of one out of three days; the mean number of days with precipitation of .01 inches or better being

127. We may note that the inversion frequency observed in the Oak Ridge area agrees very well with the frequency for other locations in this Appalachian area. The winds are predominately NE and SW, as determined by the valley-ridge orientation, and of fairly light velocity.[3] The temperatures are generally moderate, the mean temperature for the year being 59° F according to the probability curve and 58.5° F from the computed normals. The mean temperatures for the cold months of December and January, according to the normals, are 40.1° and 39.9° F which closely agree with the probability curves. The mean temperature for the warmest month, July, is 74.5° according to the probability curves and 77.7° according to the normal. The normal maximum temperature for July of 88.7° corresponds to a 92% probability on the graph. However, probability of dry bulb temperatures above 100° F is less than .01%. As an indication of the moisture in the air, the mean wet bulb temperature also reaches a maxium in July, with a mean of 70° F, which results in a maximum mean relative humidity of from 72% to 80% during mid summer.

Acknowledgement

The writer acknowledges with appreciation the suggestions and encouragement given by Dr. Frank A. Gifford of the Oak Ridge Weather Bureau Research Station. Appreciation is also extended to Walter M. Oulkowski of the Oak Ridge Station and Paul J. Rhodes now of the Greenville, S. C., Weather Bureau Airport Station for their preliminary work on the format and temperature data; to Billie Jean Crowe, for her invaluable typing of the drafts; Barlow K. Goad, Geraldine Addison, and Duane H. Turner, all of the CRWBRS, for helpful comments during the preparation of this study. This work was performed under an agreement between the U. S. Weather Bureau and the U. S. Atomic Energy Commission.

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[3] See ORO-99 for discussions of maximum and extreme velocities [1].

References

1. U. S. Weather Bureau, 1953: A Meteorological Survey of the Oak Ridge Area. ORO-99, Technical Information Service, Oak Ridge, Tennessee.

2. Conrad, V., and L. W. Pollak, 1950: Methods in Climatology. Harvard University Press, Cambridge, Massachusetts, 112-113.

3. Hosler, C. R., 1961: Low-Level Inversion Frequency in the Contiguous United States. Monthly Weather Review, 89, 319-339.

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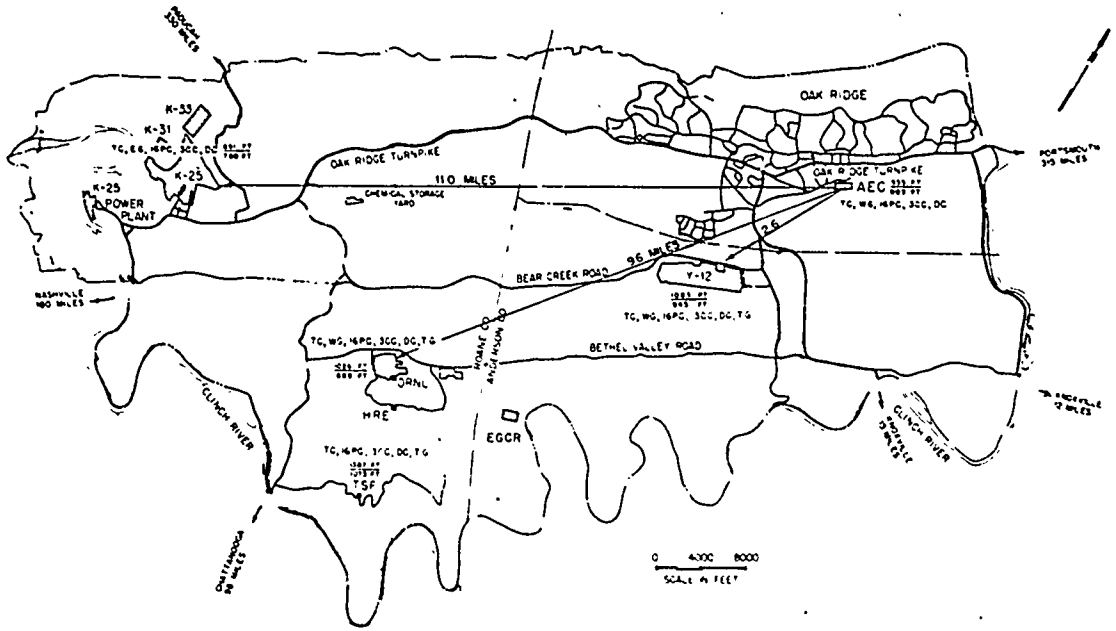
OAK RIDGE AREA

THREE MAJOR PLANT SITES AND THE CITY OF OAK RIDGE

WITH METEOROLOGICAL INSTRUMENTATION DATA



TOTAL AREA ENCOMPASSES 59,000 ACRES

UPPER FIGURE - Height of wind equipment and upper thermopile MSL

LOWER FIGURE - Height of ground MSL

DC Dew Cell

TC - Thermocouple

WG - Weighing raingage

EG - Electronic raingage

16PC - 16 Point Contacting wind vane

3CC - 3 Cup Contacting anemometer

TG - Temperature Gradient

FIGURE 1

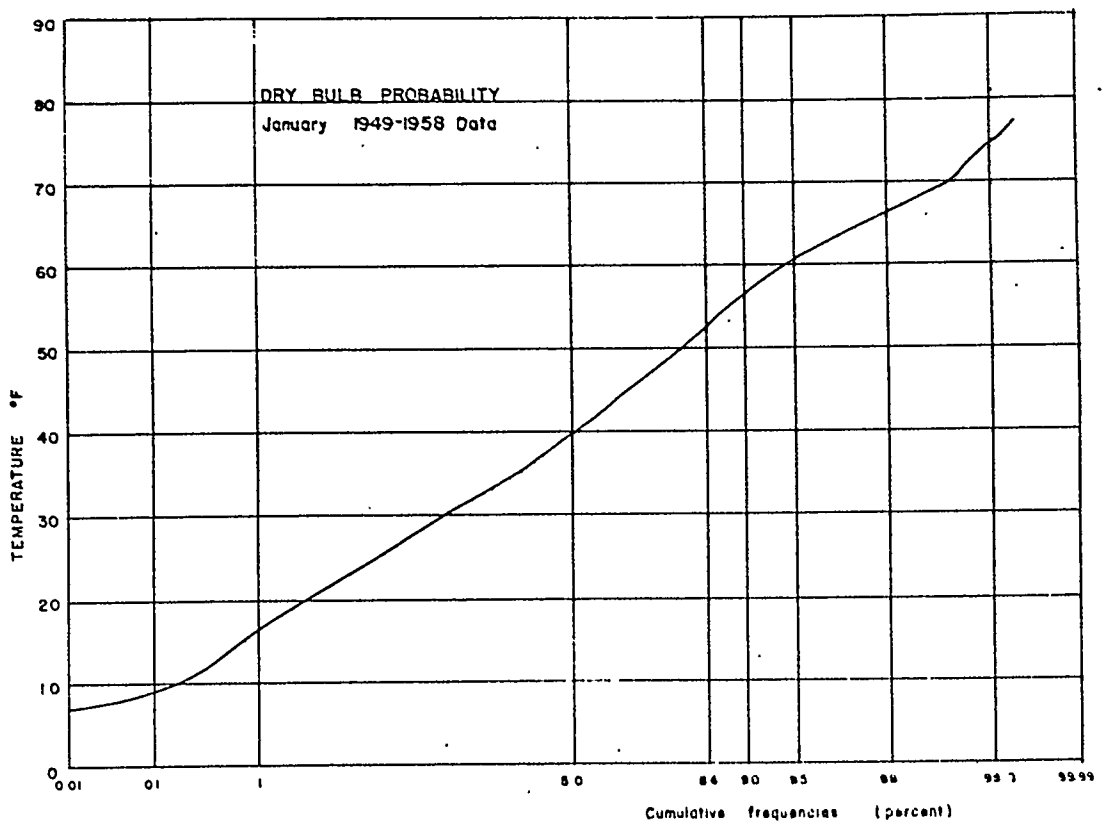

DRY BULB PROBABILITY
January 1949-1958 Data
TEMPERATURE °F
90
80
70
60
50
40
30
20
10
0
0.01
.01
.1
5.0
84
90
95
98
99.7
99.99
Cumulative frequencies (percent)

FIGURE 2

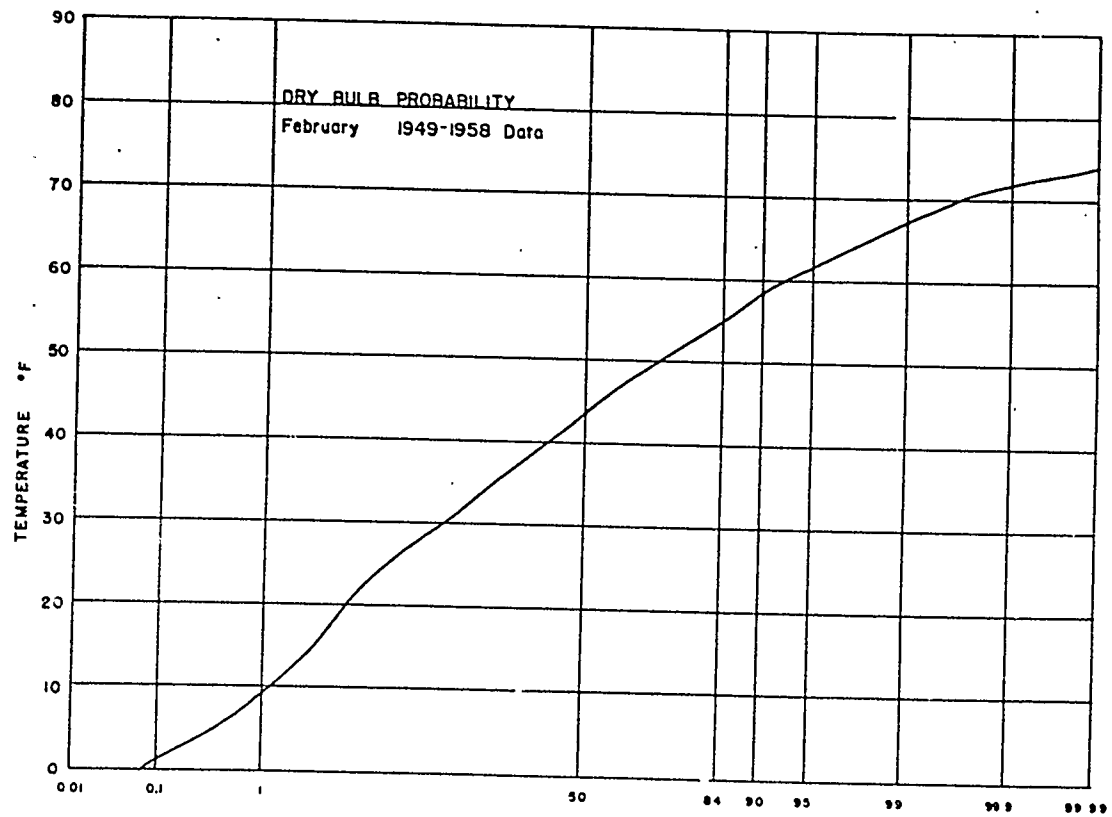


FIGURE 3 Cumulative frequencies (percent)

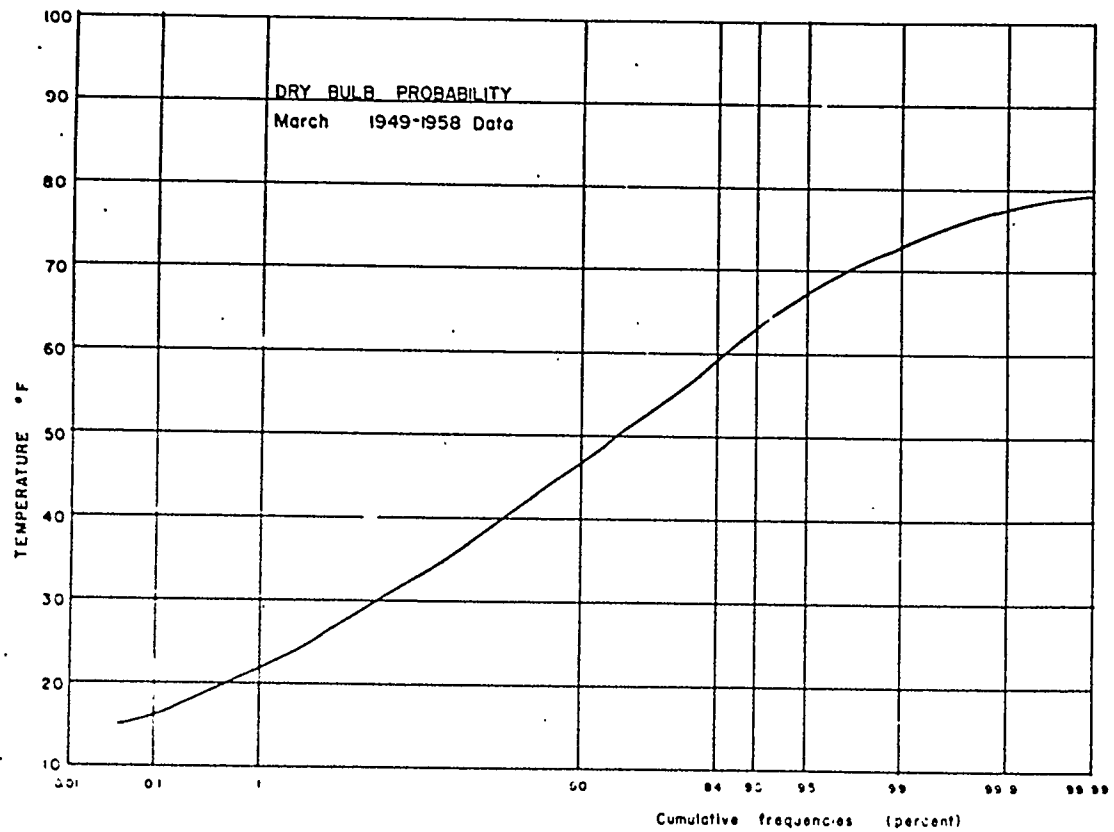

DRY BULB PROBABILITY
March 1949-1958 Data
TEMPERATURE °F
100
90
80
70
60
50
40
30
20
10
.01
.1
1
50
84
95
99
99.9
99.99
Cumulative frequencies (percent)

FIGURE 4

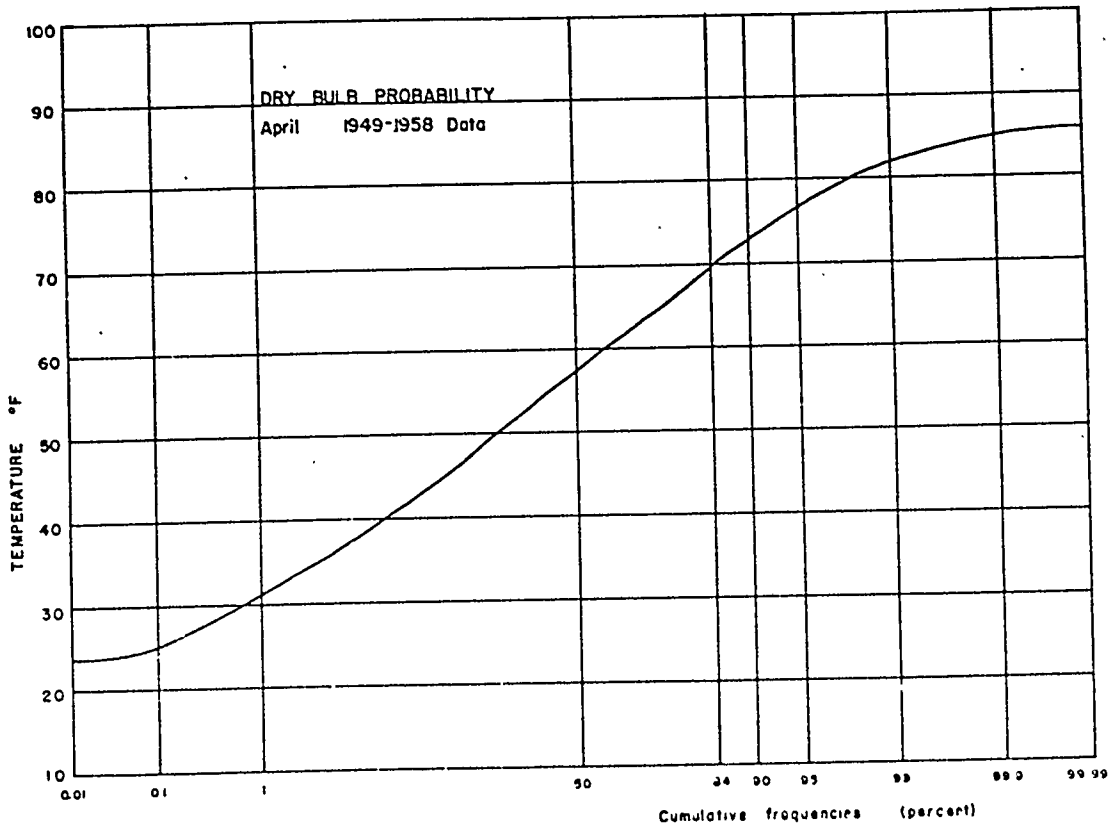

DRY BULB PROBABILITY
April 1949-1958 Data
TEMPERATURE °F
100
90
80
70
60
50
40
30
20
10
0.01
0.1
1
50
90
95
99.9
99.99
Cumulative frequencies (percent)

FIGURE 5

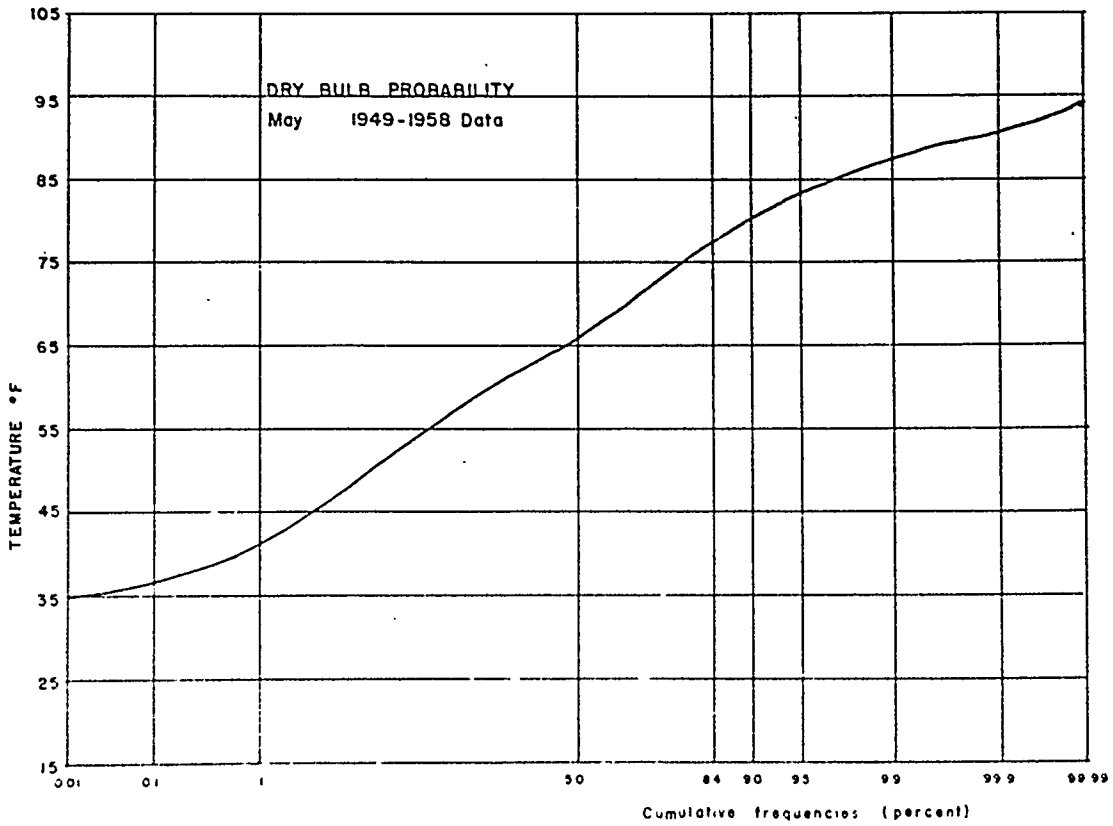

DRY BULB PROBABILITY
May 1949-1958 Data
TEMPERATURE °F
105
95
85
75
65
55
45
35
25
15
0.01
0.1
1
50
84
90
95
99
99.9
99.99
Cumulative frequencies (percent)

FIGURE 6

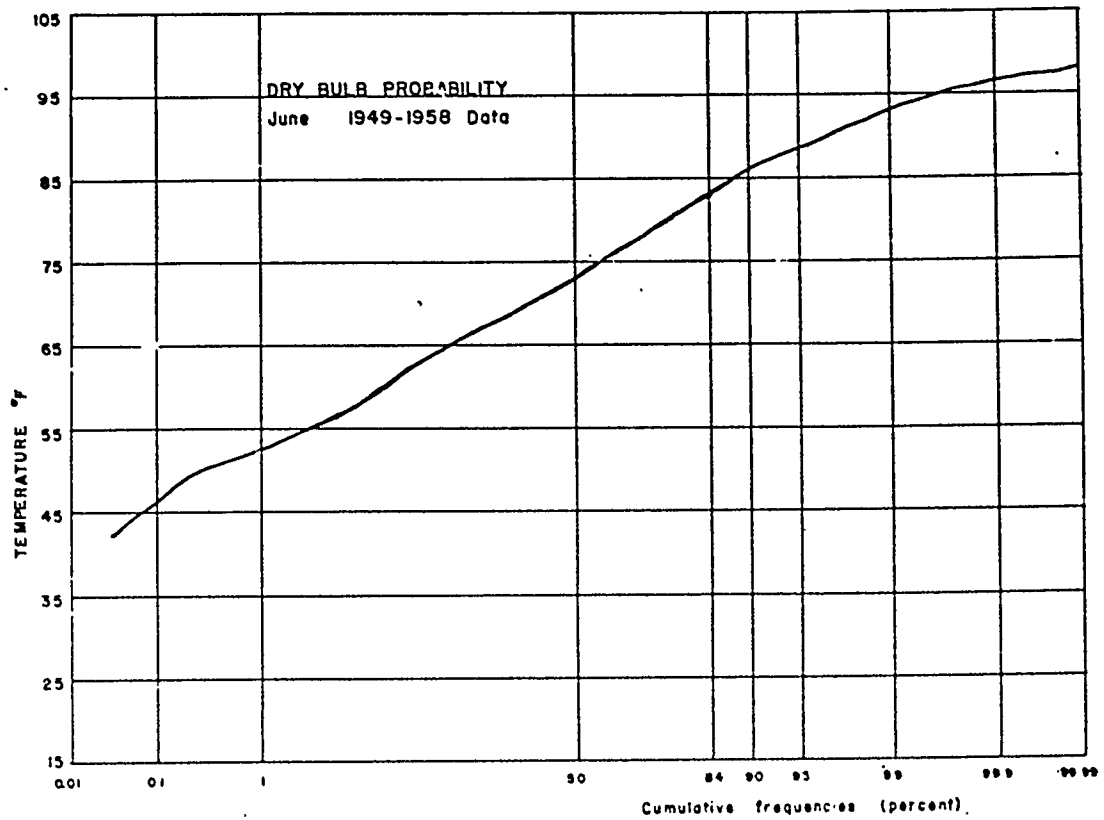

DRY BULB PROBABILITY
June 1949-1958 Data
TEMPERATURE °F
105
95
85
75
65
55
45
35
25
15
0.01
0.1
1
50
84
90
93
99
99.9
99.99
Cumulative frequencies (percent)

FIGURE 7

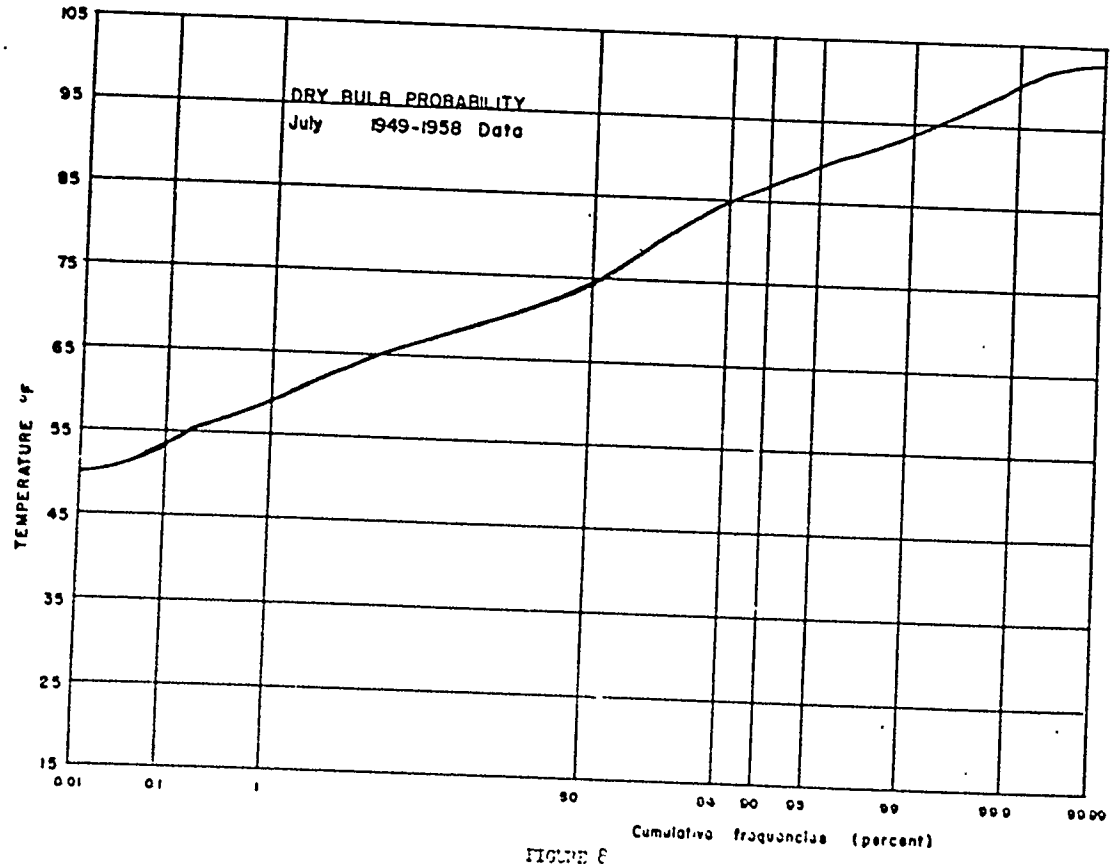

DRY BULB PROBABILITY
July 1949-1958 Data
TEMPERATURE °F
105
95
85
75
65
55
45
35
25
15
0.01
0.1
1
50
90
95
99
99.9
99.99
Cumulative frequencies (percent)

FIGURE 8

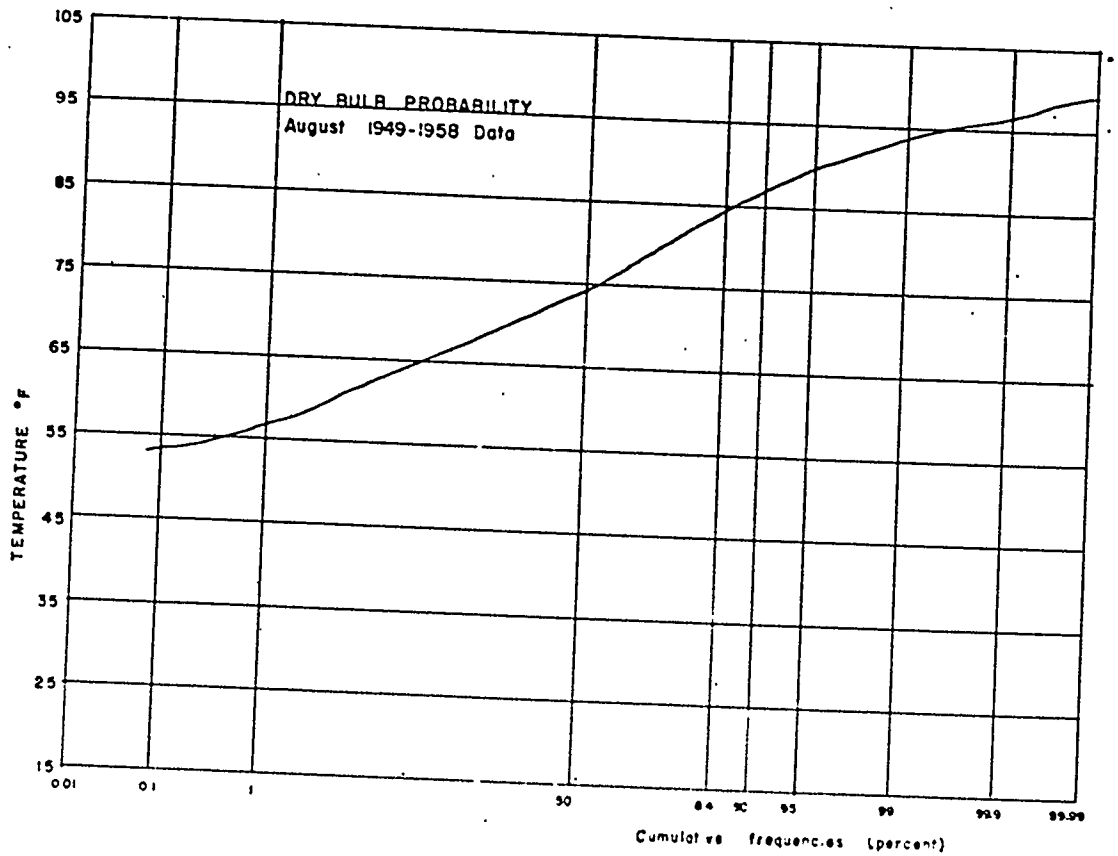

DRY BULB PROBABILITY
August 1949-1958 Data
TEMPERATURE °F
105
95
85
75
65
55
45
35
25
15
0.01
0.1
1
50
84
90
95
99
99.9
99.99
Cumulative frequencies (percent)

FIGURE 9

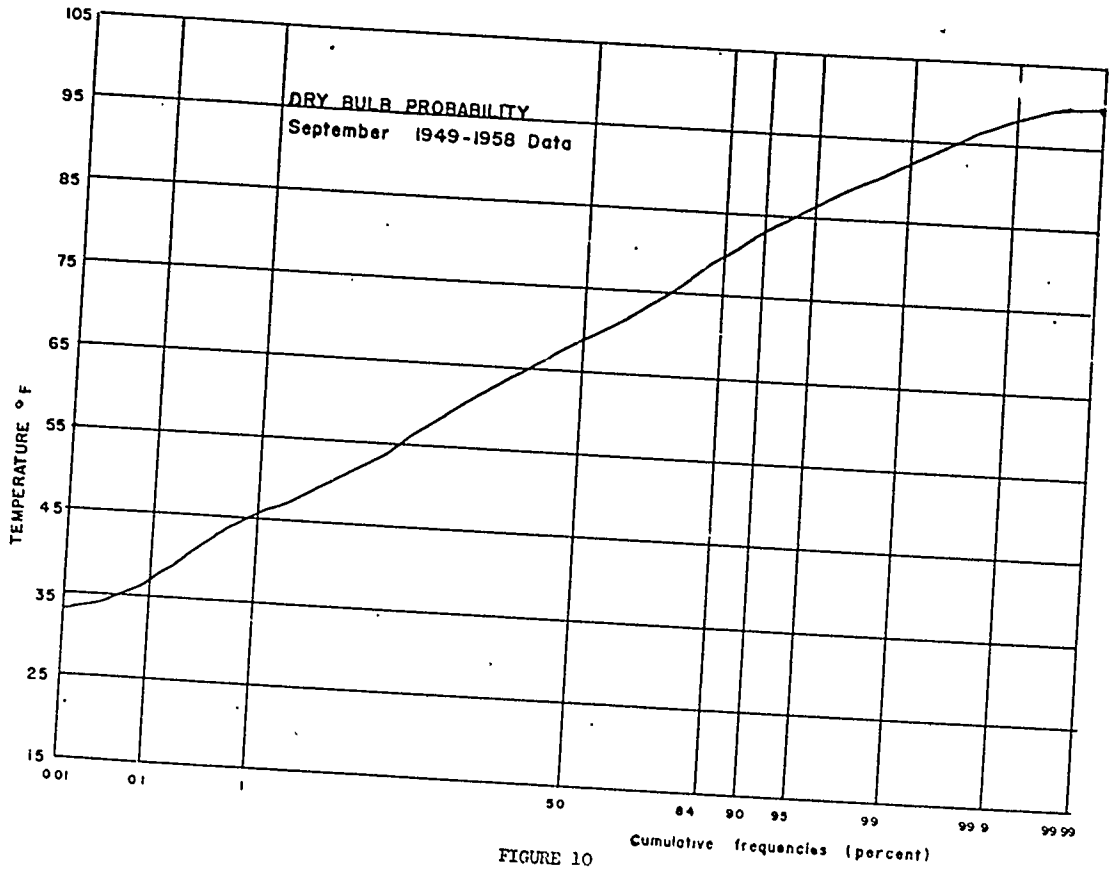

DRY BULB PROBABILITY
September 1949-1958 Data
TEMPERATURE °F
105
95
85
75
65
55
45
35
25
15
0.01
0.1
1
50
84
90
95
99
99.9
99.99
Cumulative frequencies (percent)

FIGURE 10

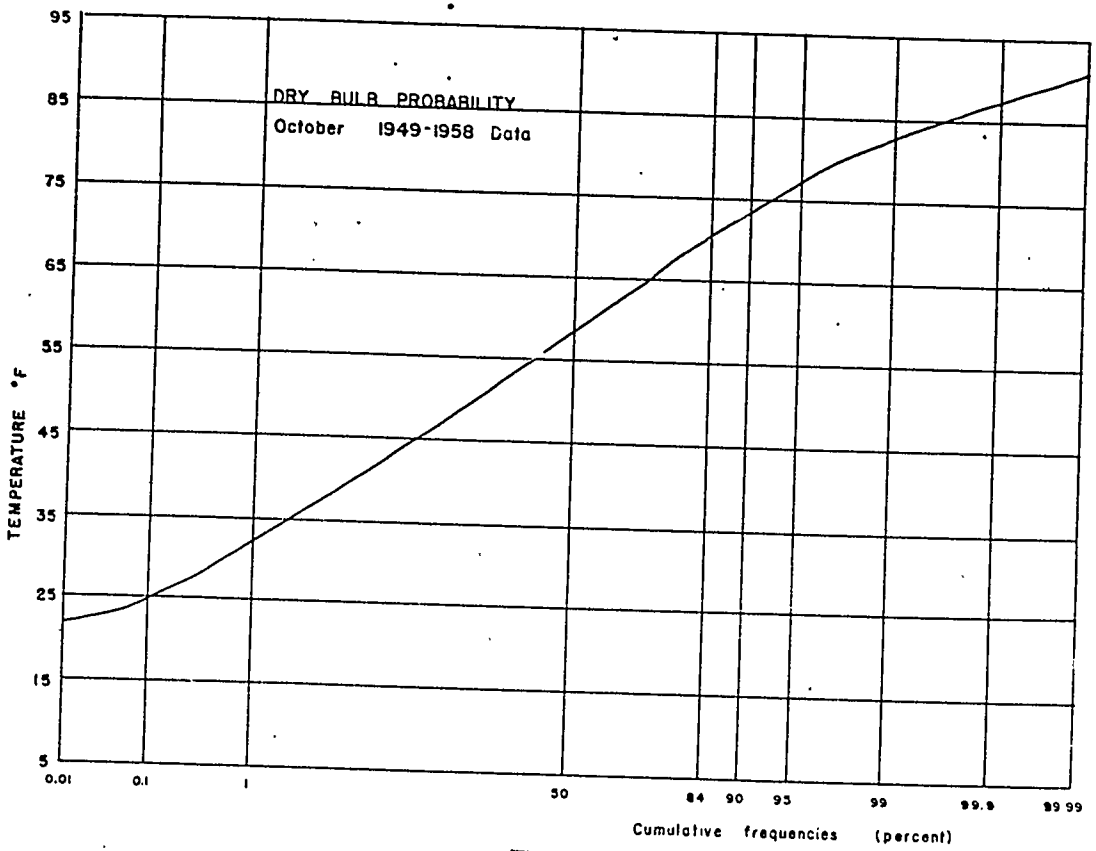

DRY BULB PROBABILITY
October 1949-1958 Data
TEMPERATURE °F
95
85
75
65
55
45
35
25
15
5
0.01
0.1
1
50
84
90
95
99
99.9
99.99
Cumulative frequencies (percent)

FIGURE 11

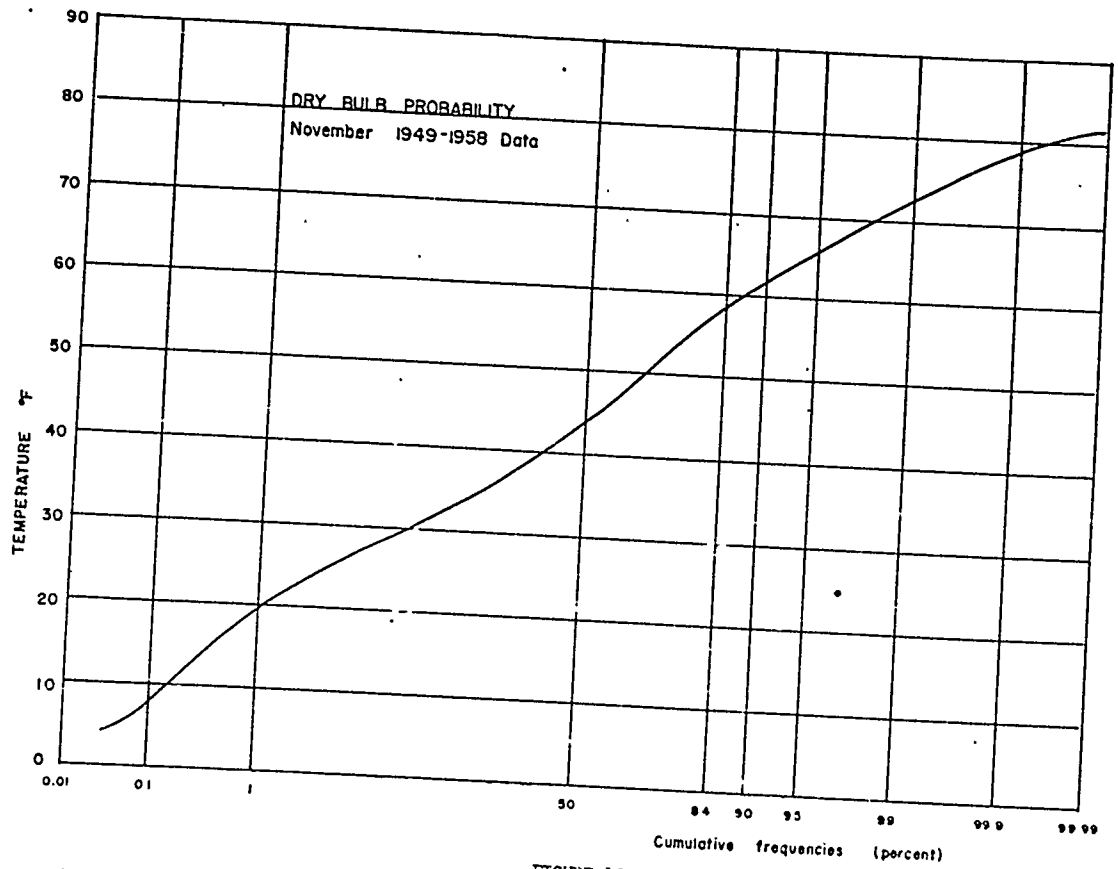

DRY BULB PROBABILITY
November 1949-1958 Data
TEMPERATURE °F
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
50
84
90
95
99
99.9
99.99
Cumulative frequencies (percent)

FIGURE 12

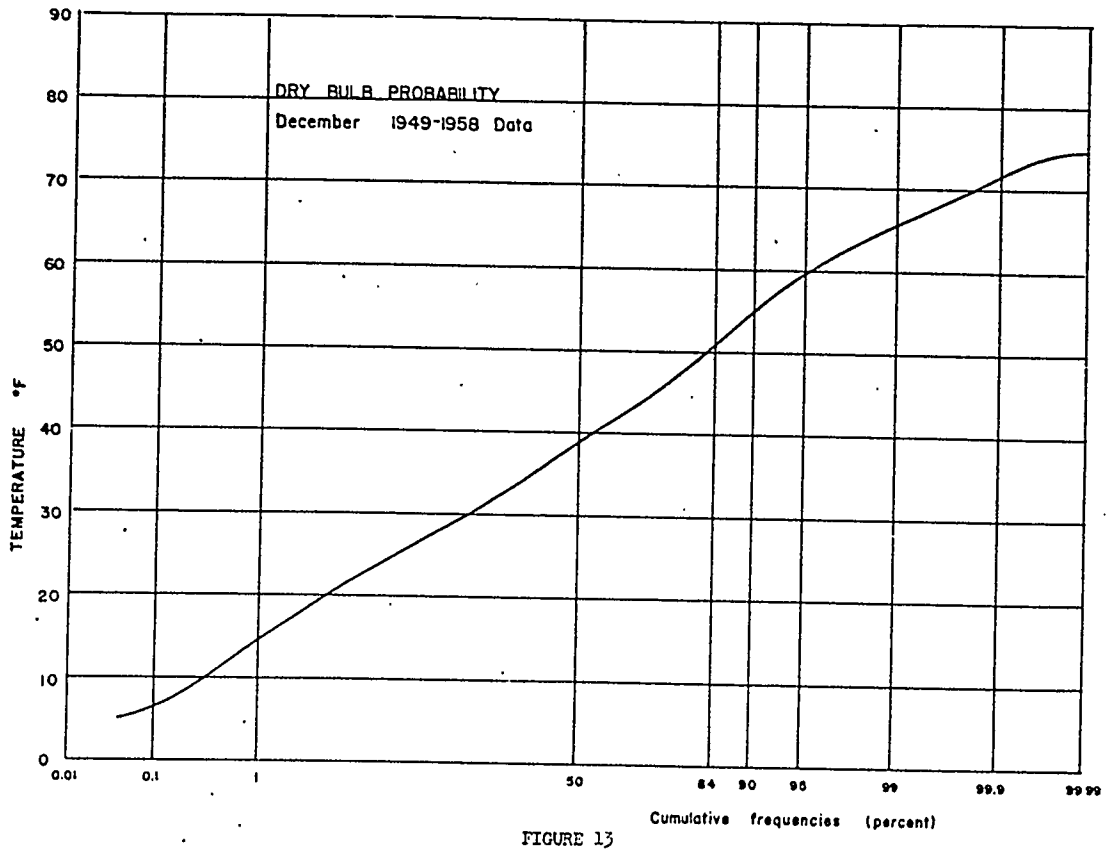

DRY BULB PROBABILITY
December 1949-1958 Data
TEMPERATURE °F
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
50
84
90
95
99
99.9
99.99
Cumulative frequencies (percent)

FIGURE 13

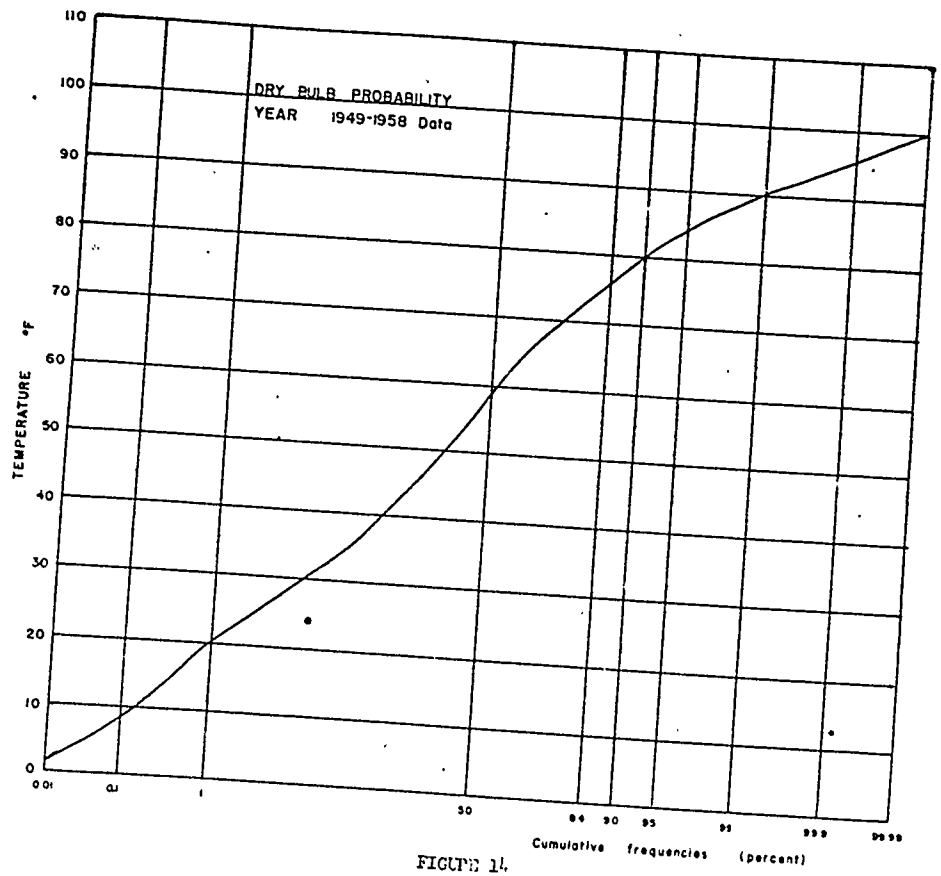

DRY BULB PROBABILITY
YEAR 1949-1958 Data
TEMPERATURE °F
110
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
50
84
90
95
99
99.9
99.99
Cumulative frequencies (percent)

FIGURE 14

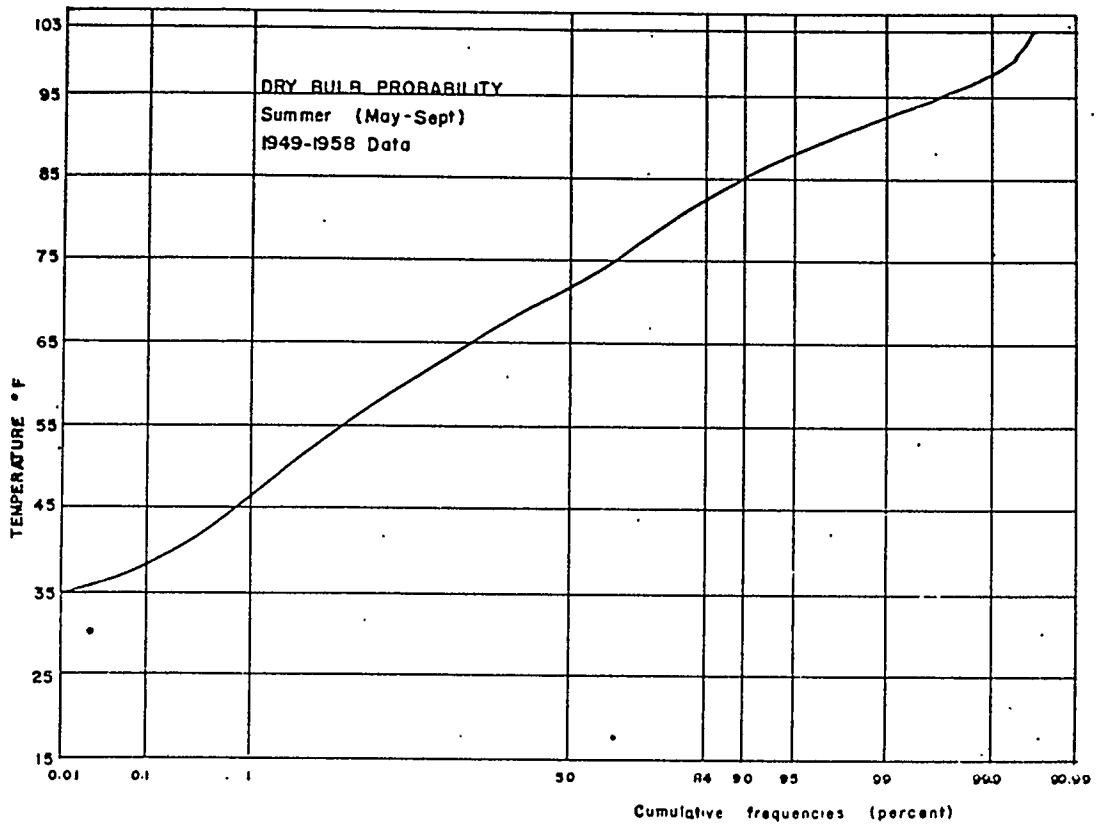

DRY BULB PROBABILITY
Summer (May-Sept)
1949-1958 Data
TEMPERATURE °F
103
95
85
75
65
55
45
35
25
15
0.01
0.1
1
50
84
90
95
99
99.9
99.99
Cumulative frequencies (percent)

FIGURE 15

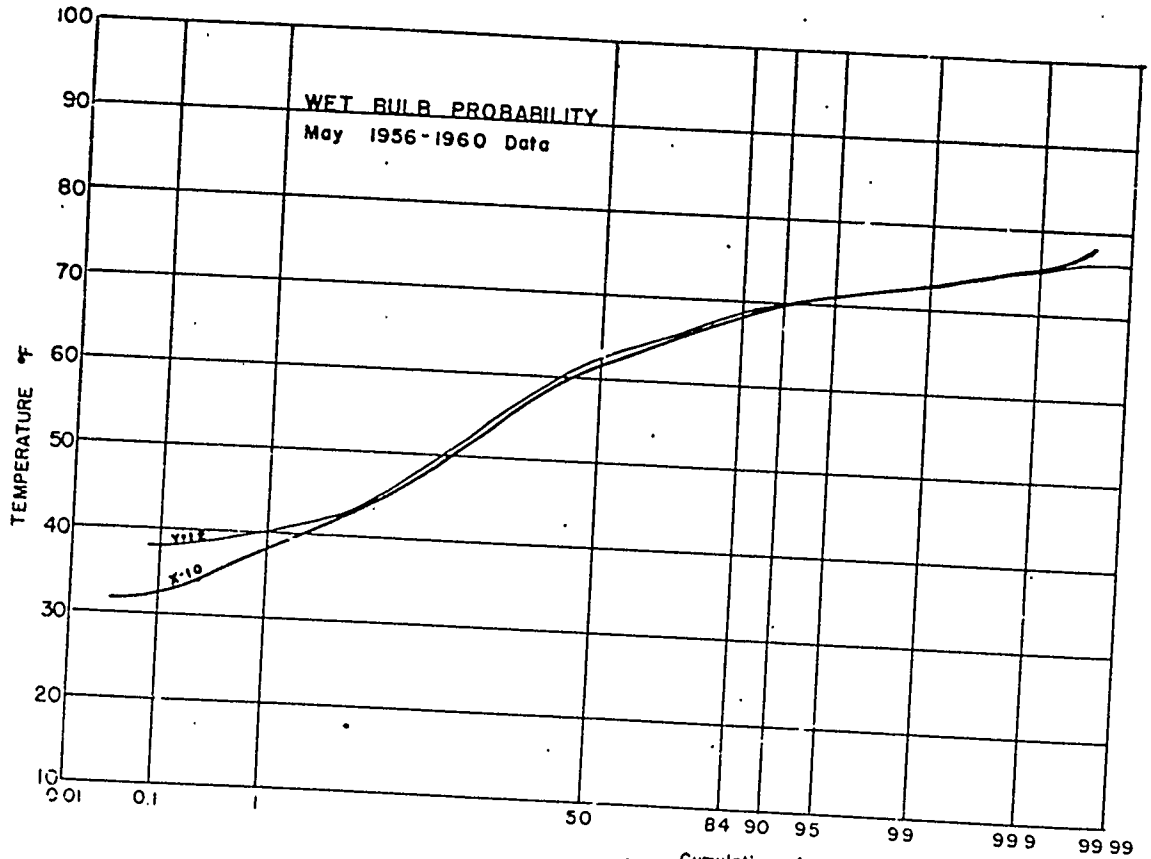

WET BULB PROBABILITY
May 1956-1960 Data
TEMPERATURE °F
100
90
80
70
60
50
40
30
20
10
0.01
0.1
1
50
84
90
95
99
99.9
99.99
Cumulative frequencies (percent)

FIGURE 16

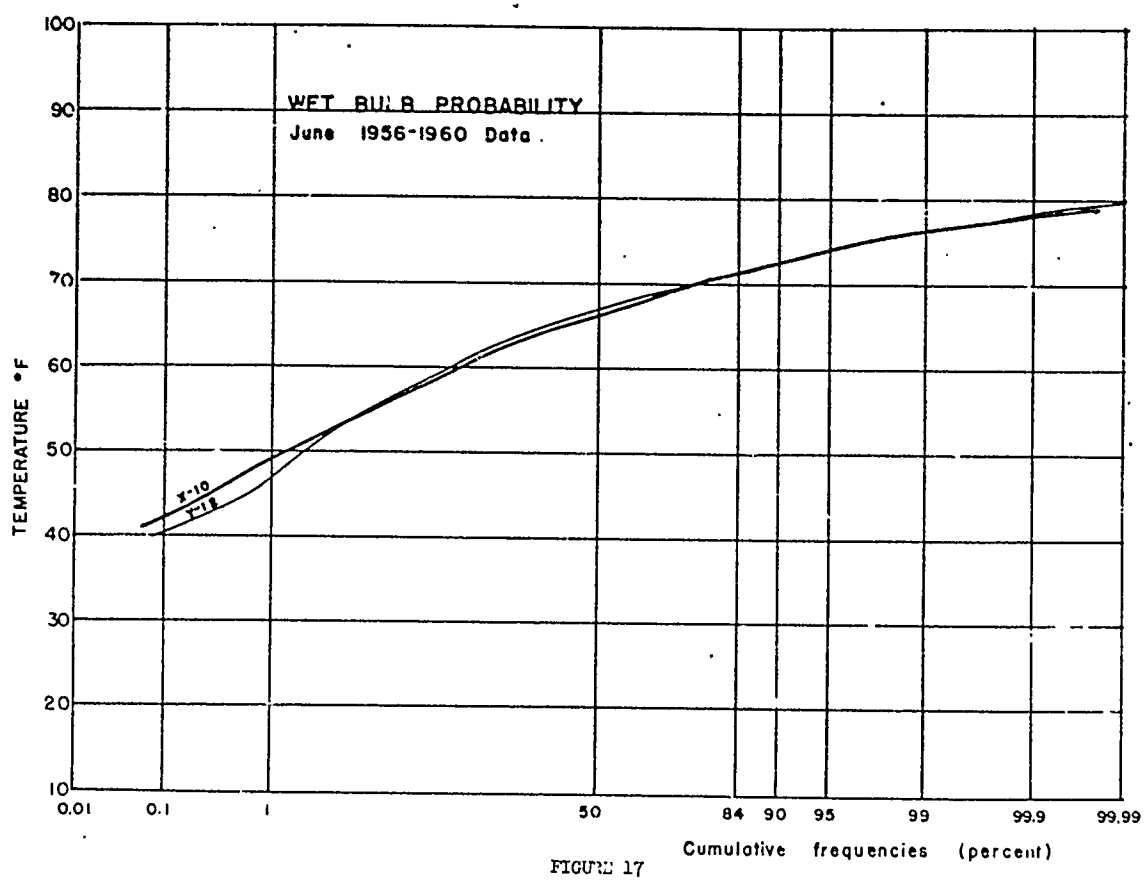

WET BULB PROBABILITY
June 1956-1960 Data.
TEMPERATURE °F
100
90
80
70
60
50
40
30
20
10
0.01
0.1
1
50
84
90
95
99
99.9
99.99
Cumulative frequencies (percent)

FIGURE 17

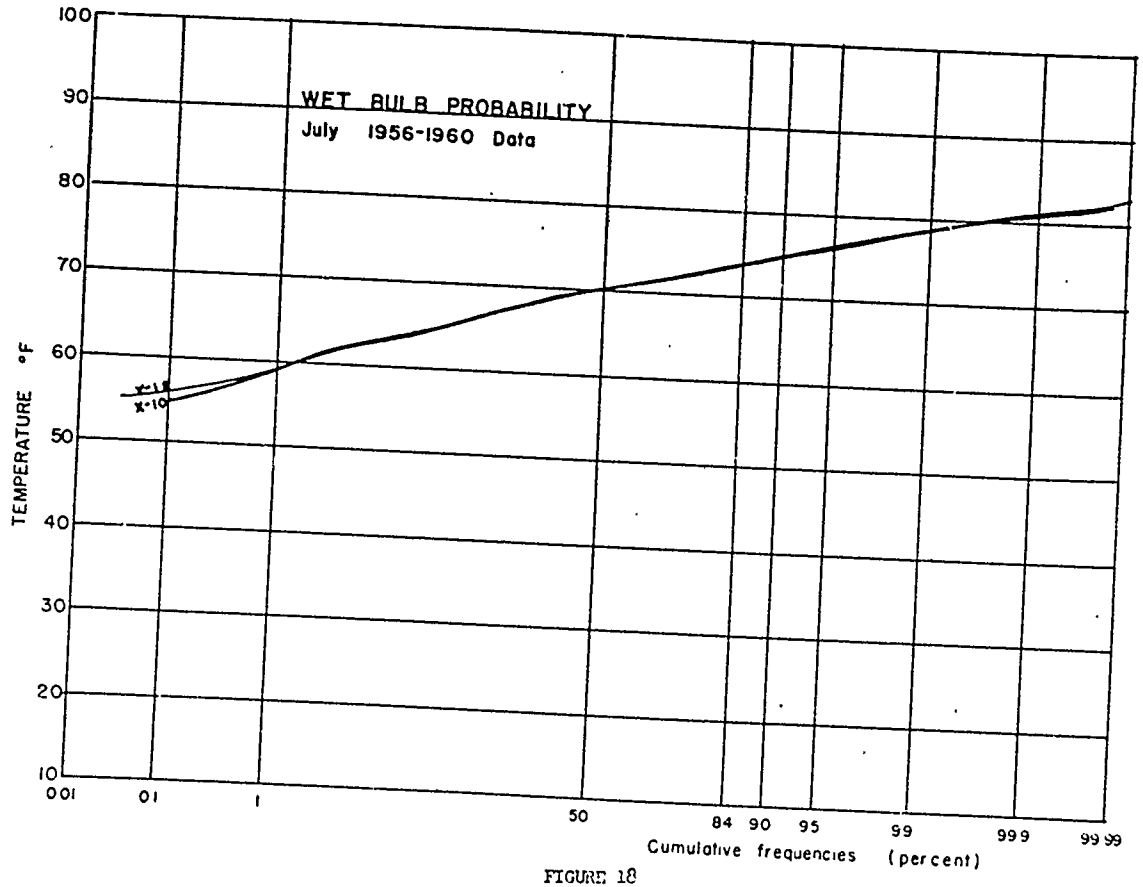

WET BULB PROBABILITY
July 1956-1960 Data
TEMPERATURE °F
100
90
80
70
60
50
40
30
20
10
x=1
x=10
0.01
0.1
1
50
84
90
95
99
99.9
99.99
Cumulative frequencies (percent)

FIGURE 18

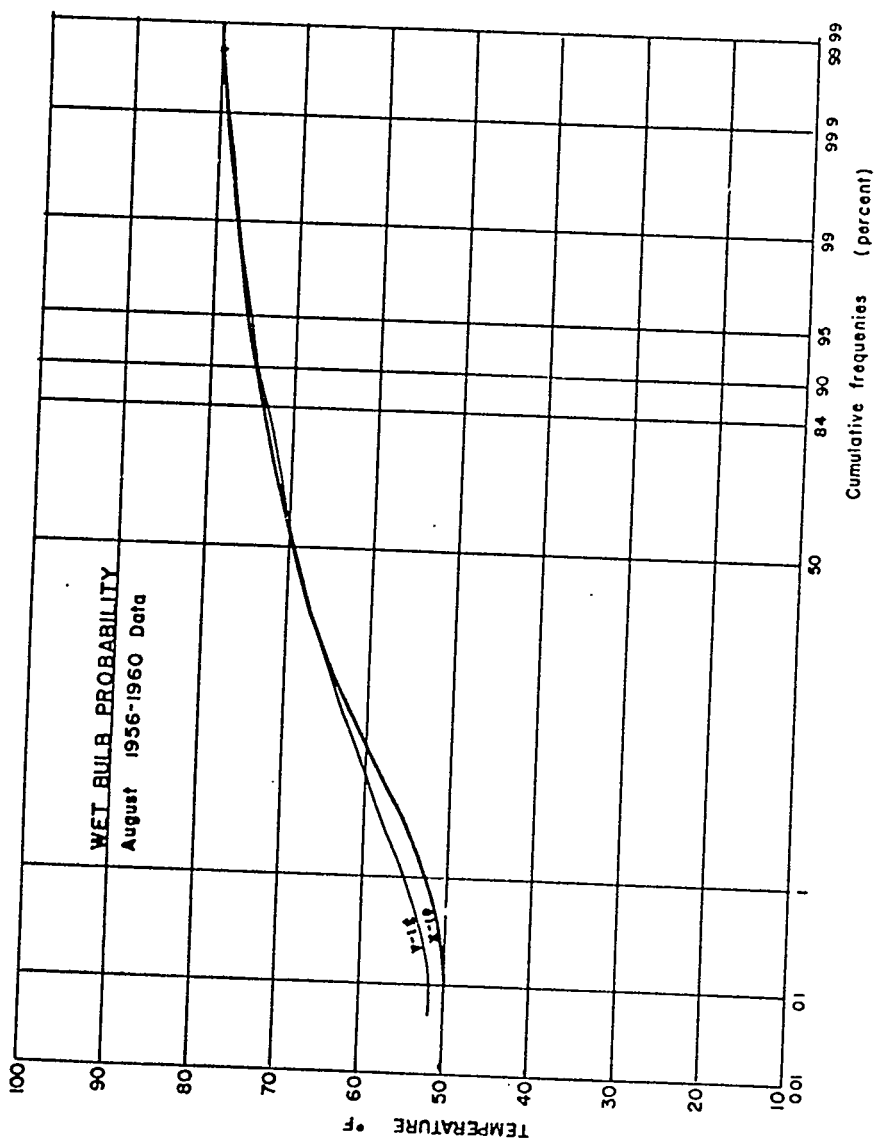

WET BULB PROBABILITY
August 1956-1960 Data
TEMPERATURE °F
100
90
80
70
60
50
40
30
20
10
Cumulative frequenies (percent)
0.01
0.1
1
50
84
90
95
99
99.9
99.99

FIGURE 19

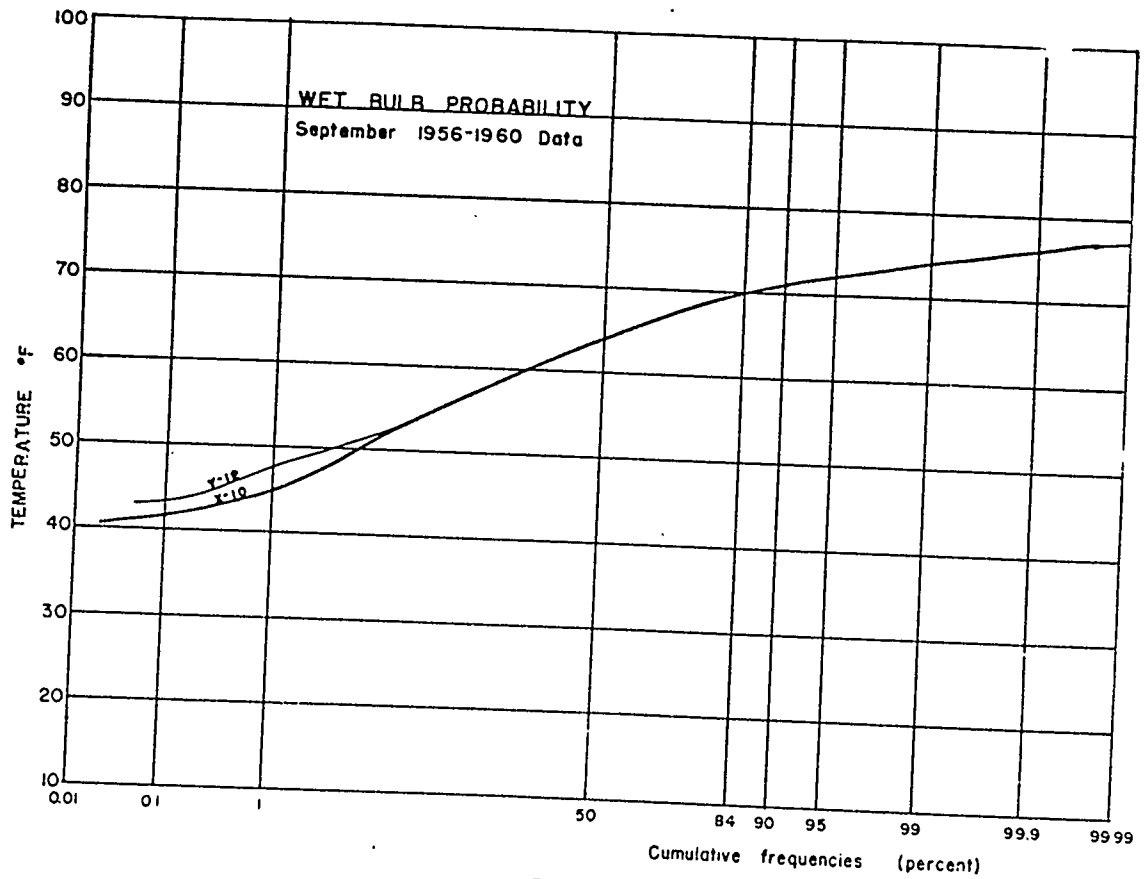

WET BULB PROBABILITY
September 1956-1960 Data
TEMPERATURE °F
100
90
80
70
60
50
40
30
20
10
0.01
0.1
1
50
84
90
95
99
99.9
99.99
Cumulative frequencies (percent)

FIGURE 20

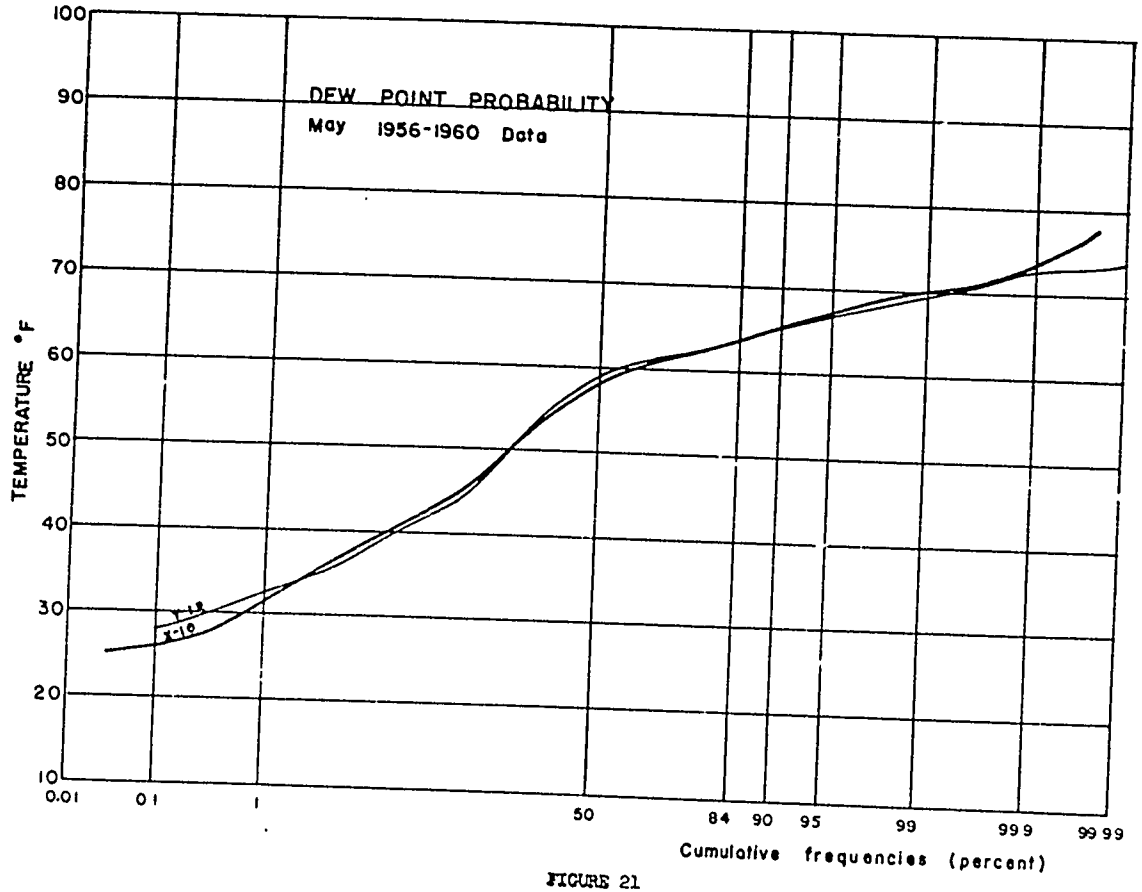

DEW POINT PROBABILITY
May 1956-1960 Data
TEMPERATURE °F
100
90
80
70
60
50
40
30
20
10
0.01
0.1
1
50
84
90
95
99
99.9
99.99
Cumulative frequencies (percent)

FIGURE 21

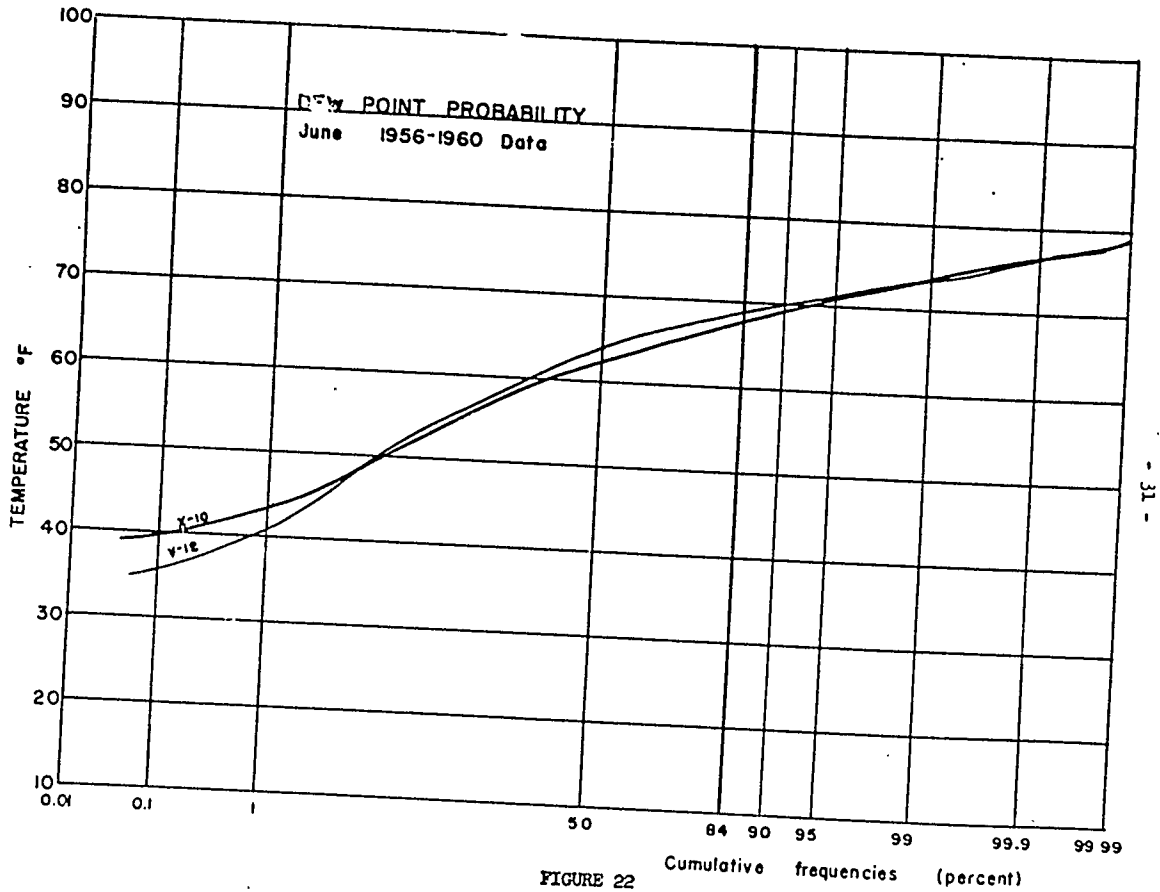

DEW POINT PROBABILITY
June 1956-1960 Data
TEMPERATURE °F
100
90
80
70
60
50
40
30
20
10
0.01
0.1
1
50
84
90
95
99
99.9
99.99
Cumulative frequencies (percent)
X-10
V-12

FIGURE 22

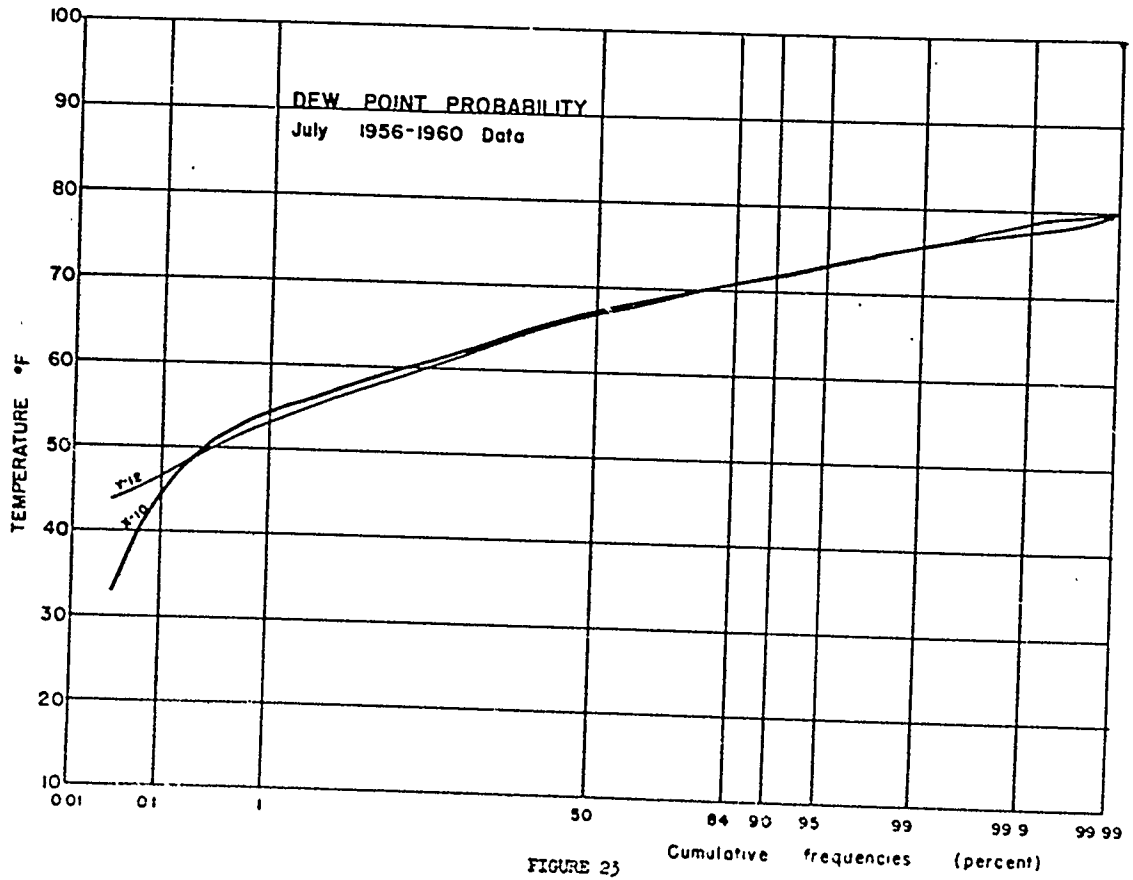

DEW POINT PROBABILITY
July 1956-1960 Data
TEMPERATURE °F
100
90
80
70
60
50
40
30
20
10
0.01
0.1
1
50
84
90
95
99
99.9
99.99
Cumulative frequencies (percent)

FIGURE 23

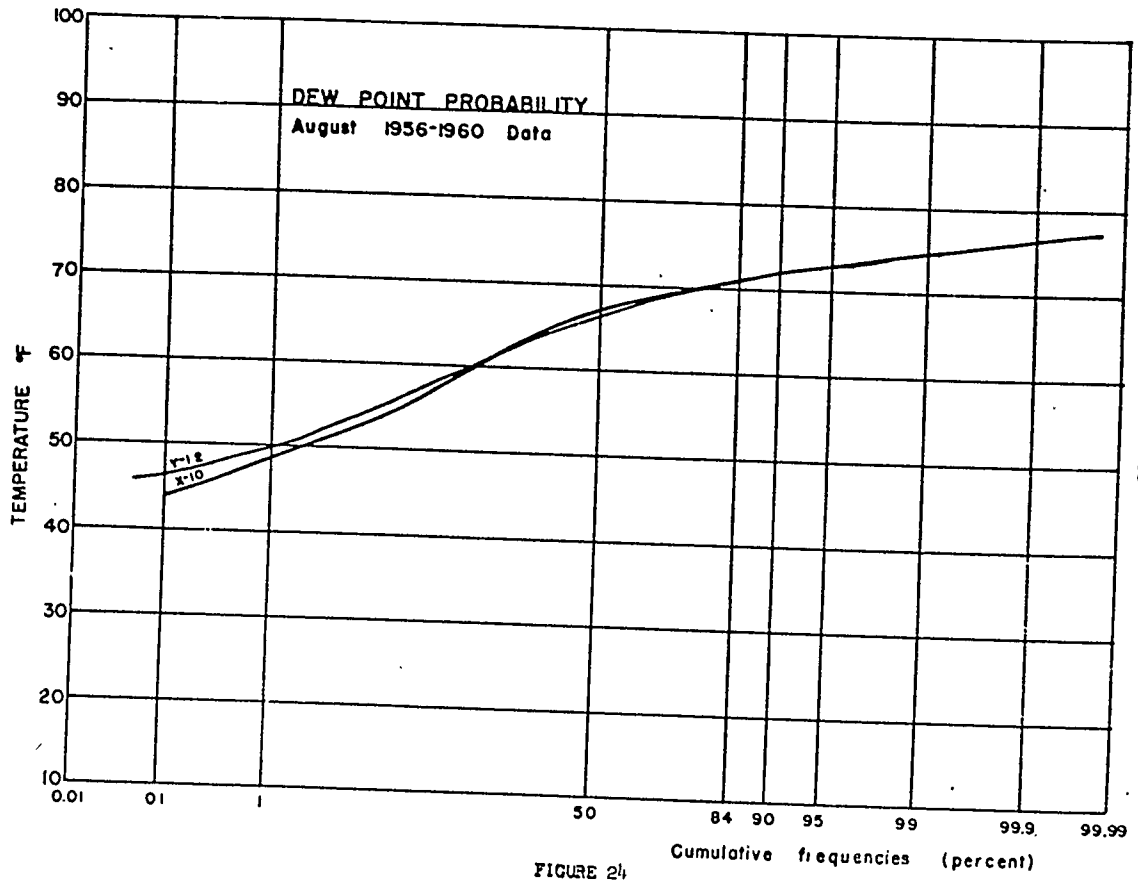

DEW POINT PROBABILITY
August 1956-1960 Data
TEMPERATURE °F
100
90
80
70
60
50
40
30
20
10
0.01
0.1
1
50
84
90
95
99
99.9
99.99
Cumulative frequencies (percent)
X-12
X-10

FIGURE 24

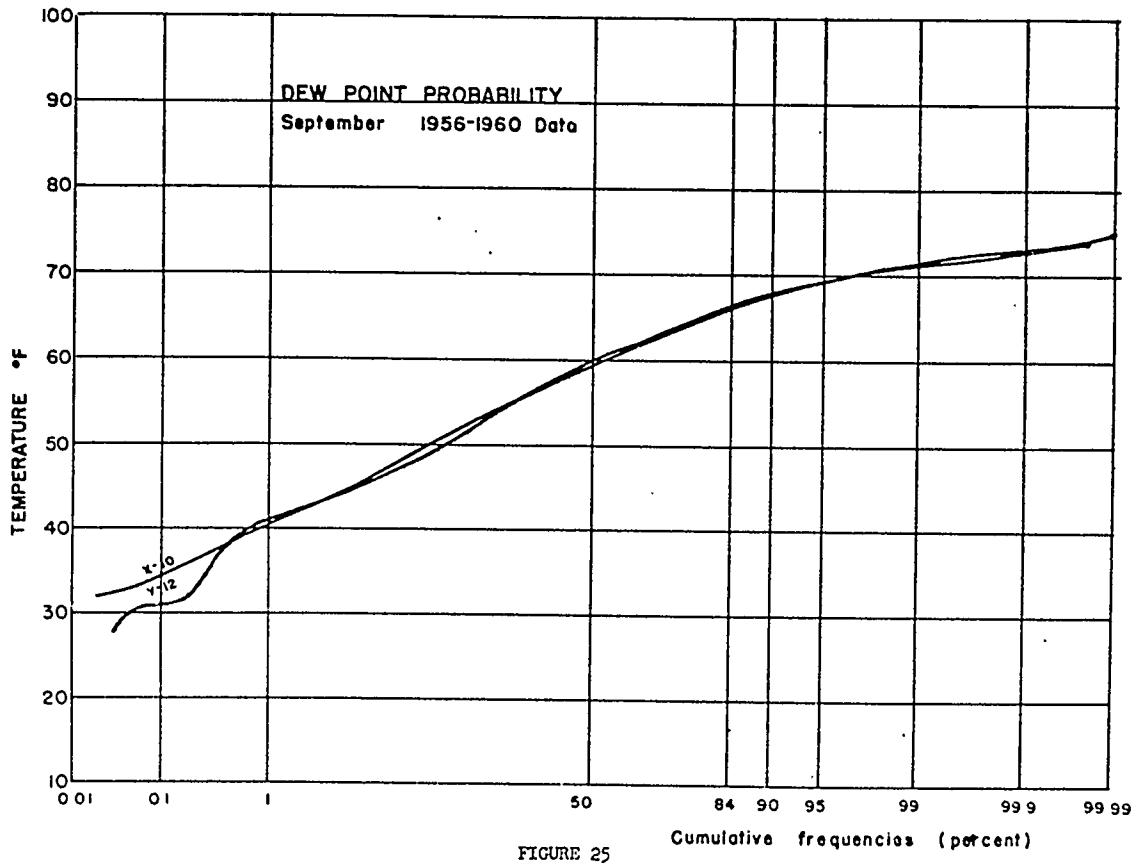
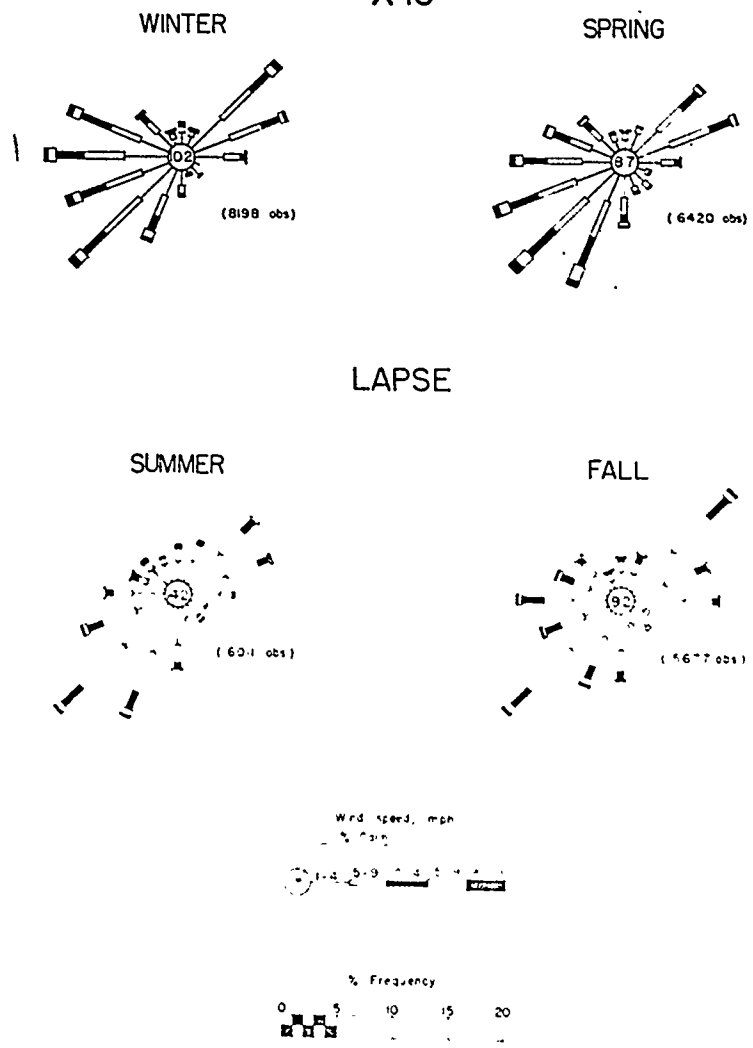

DEW POINT PROBABILITY
September 1956-1960 Data
TEMPERATURE °F
100
90
80
70
60
50
40
30
20
10
0.01
0.1
1
50
84
90
95
99
99.9
99.99
Cumulative frequencies (percent)
Y-10
Y-12

FIGURE 25

X-10

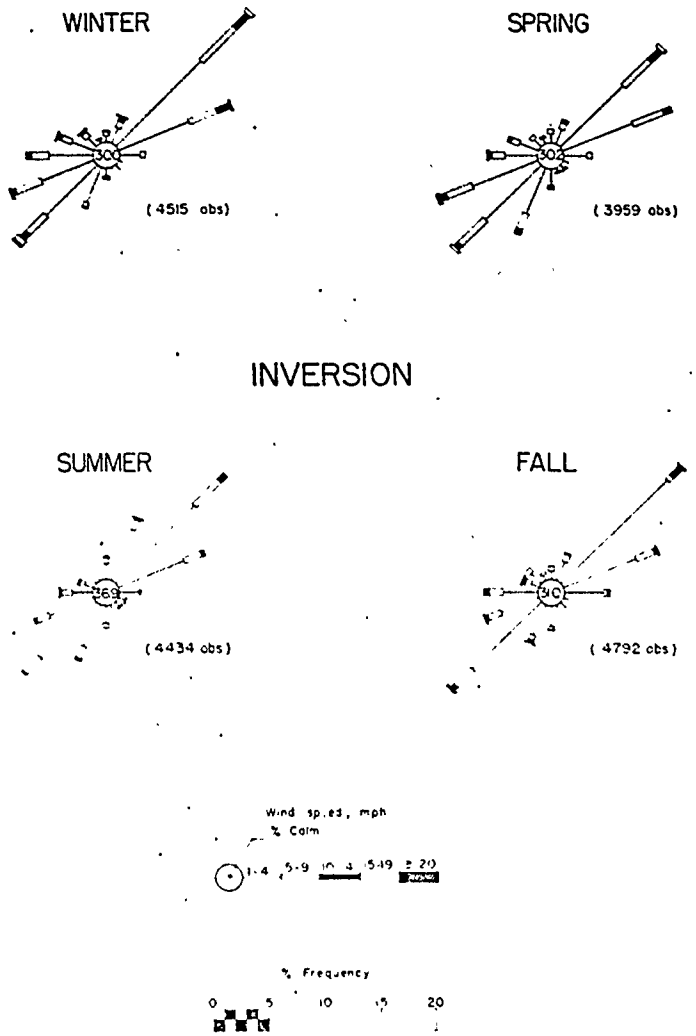
LAPSE



1956-1960 Data

FIGURE 26

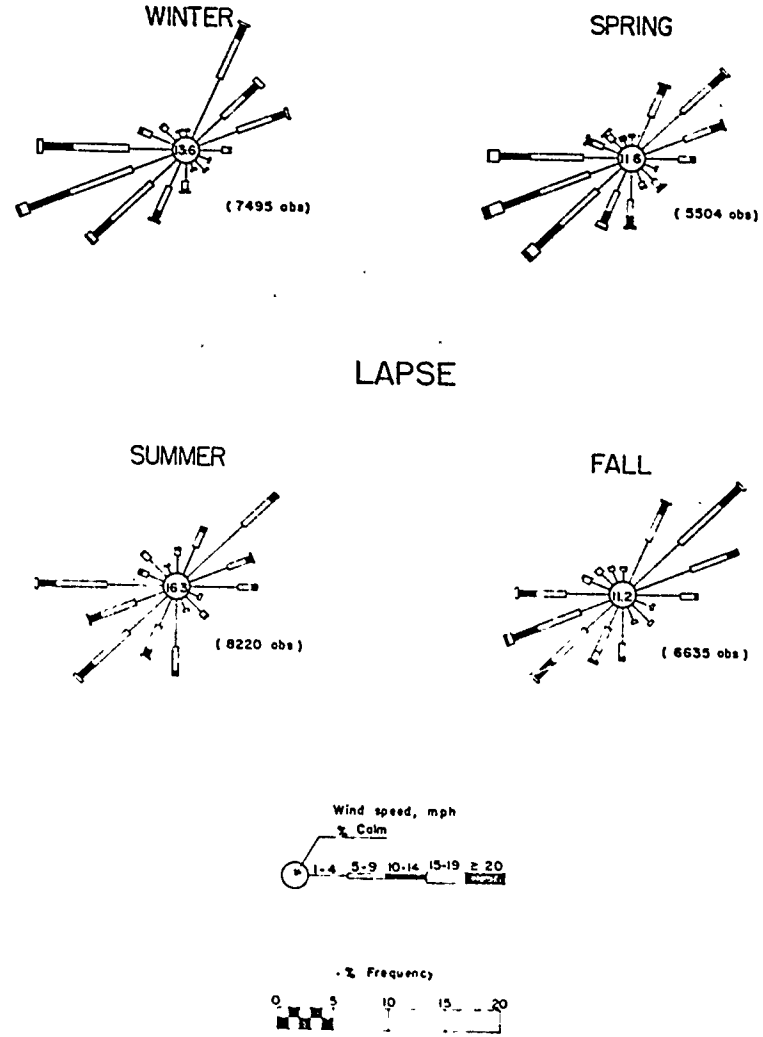
X-10



1956-1960 Data

FIGURE 27

Y-12

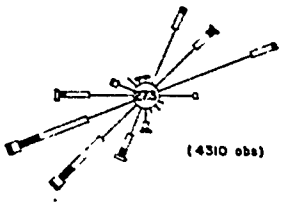


1956-1960 Data

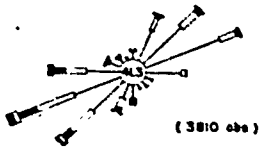
FIGURE 28

Y-12

WINTER

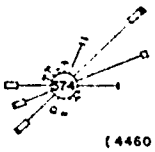


SPRING

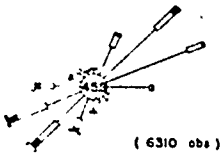


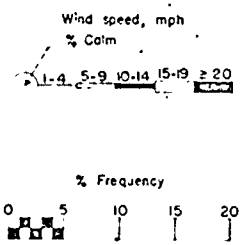
INVERSION

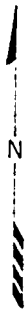
SUMMER



FALL





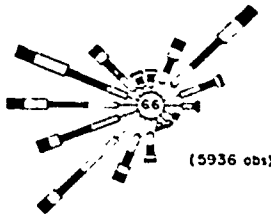


1956 - 1960 Data

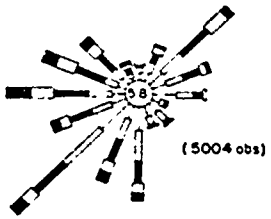
FIGURE 29

TSF

WINTER



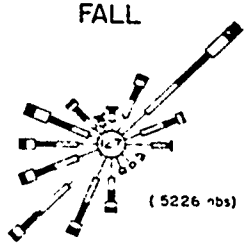
SPRING

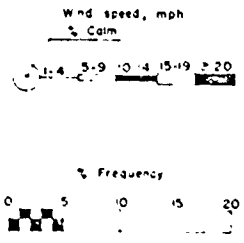


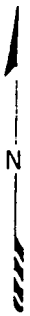
LAPSE

SUMMER

FALL



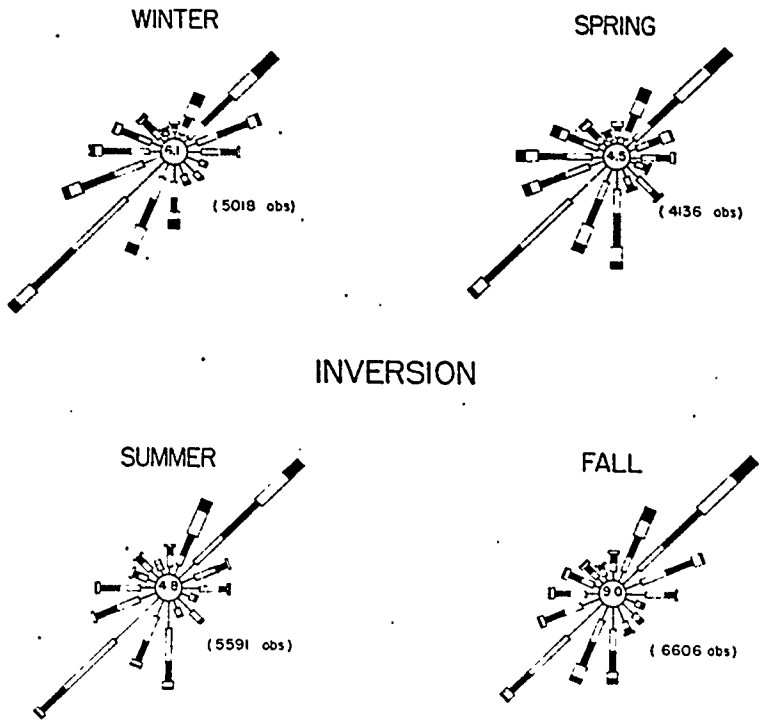


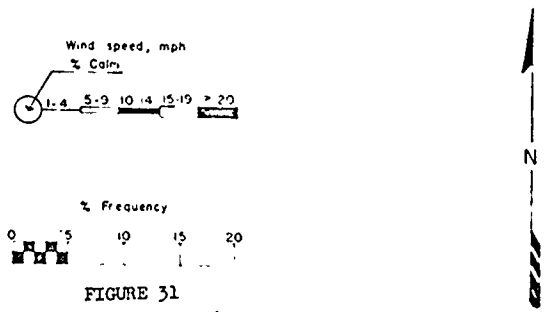


1956 - 1960 Data

FIGURE 30

TSF

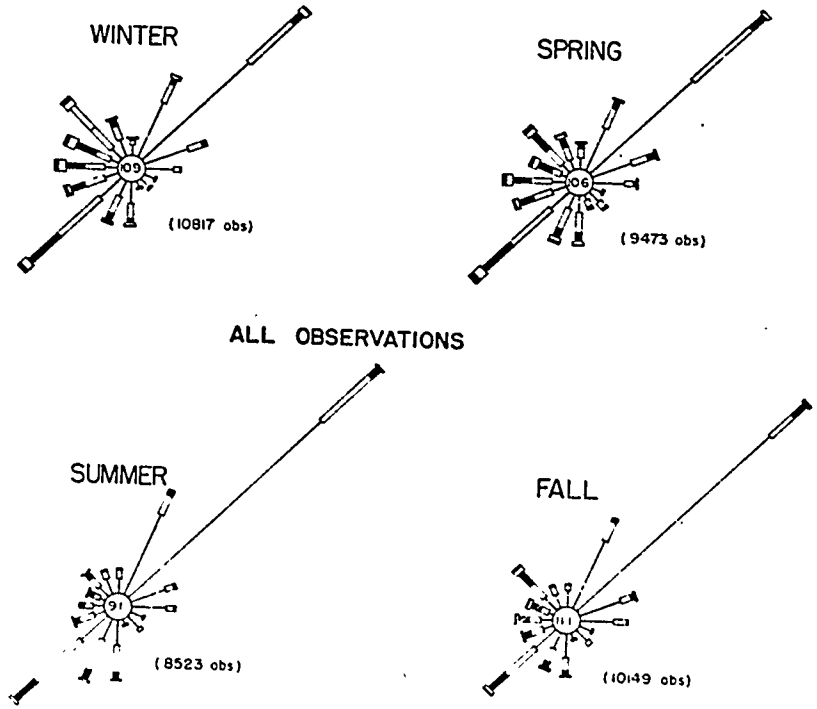




1956 - 1960 Data

FIGURE 31

K-25



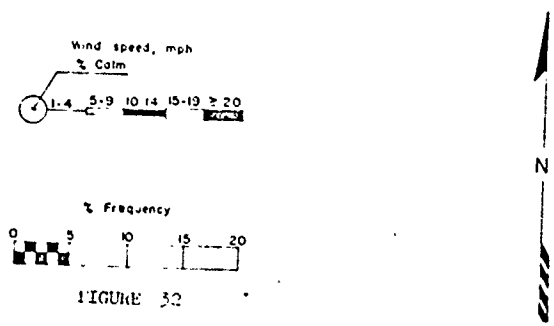
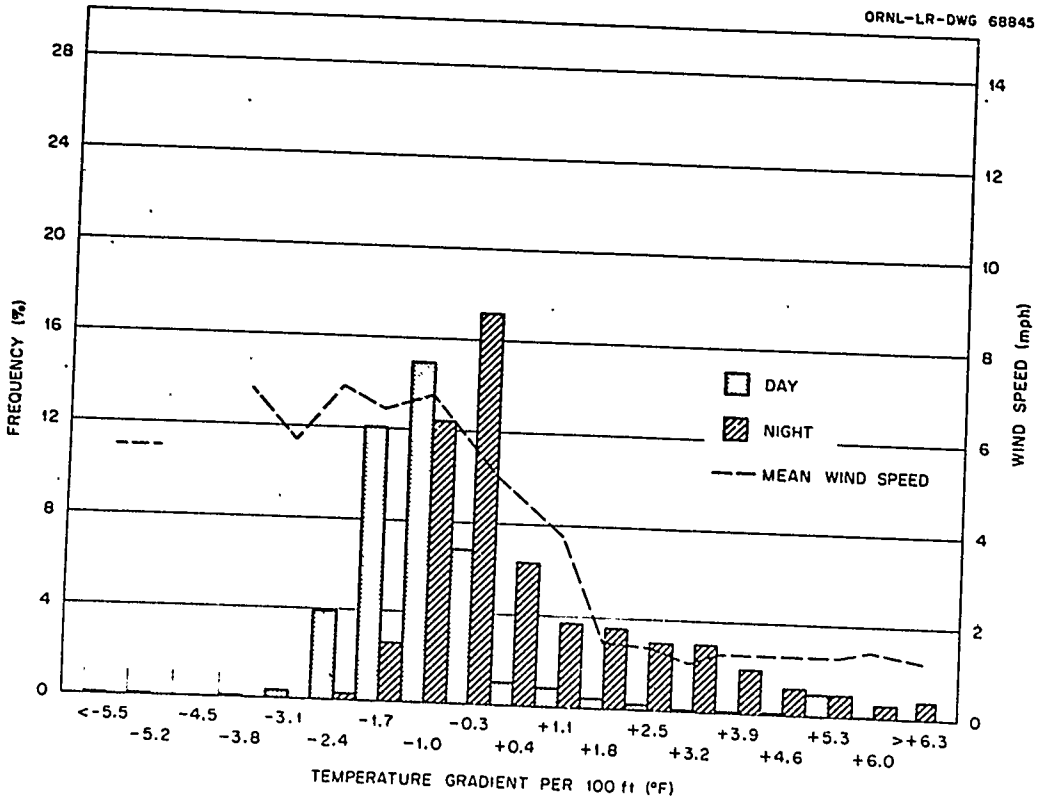
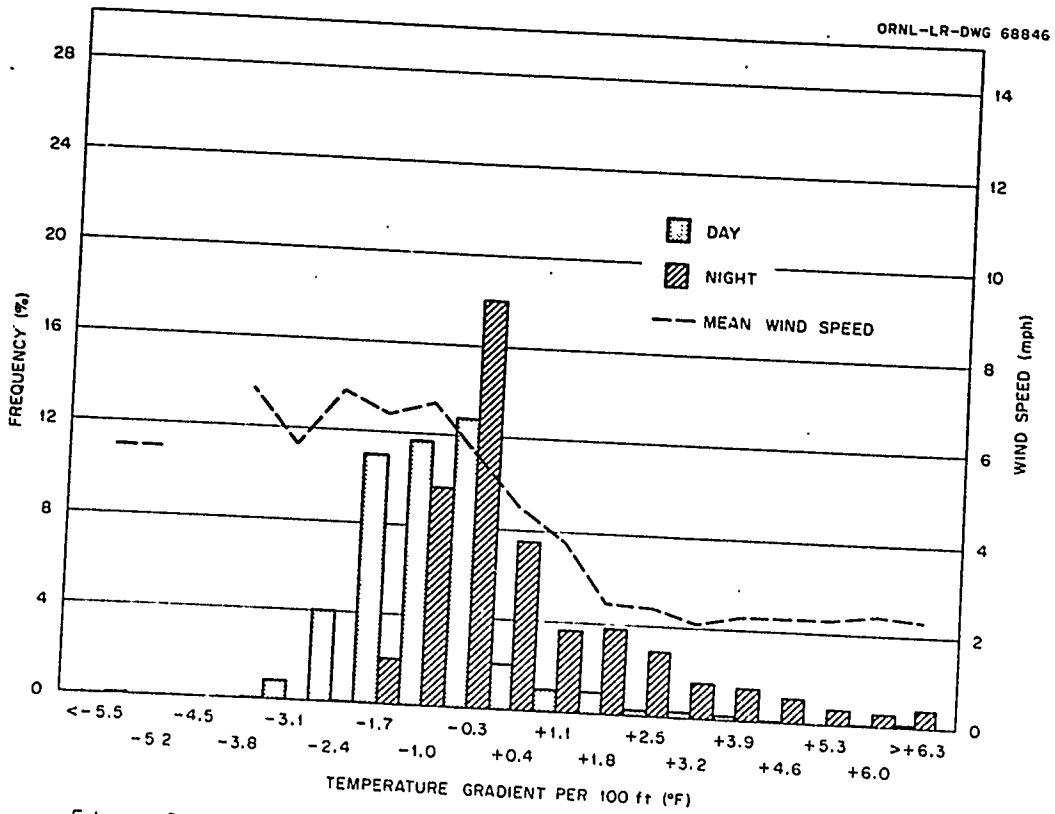


FIGURE 32



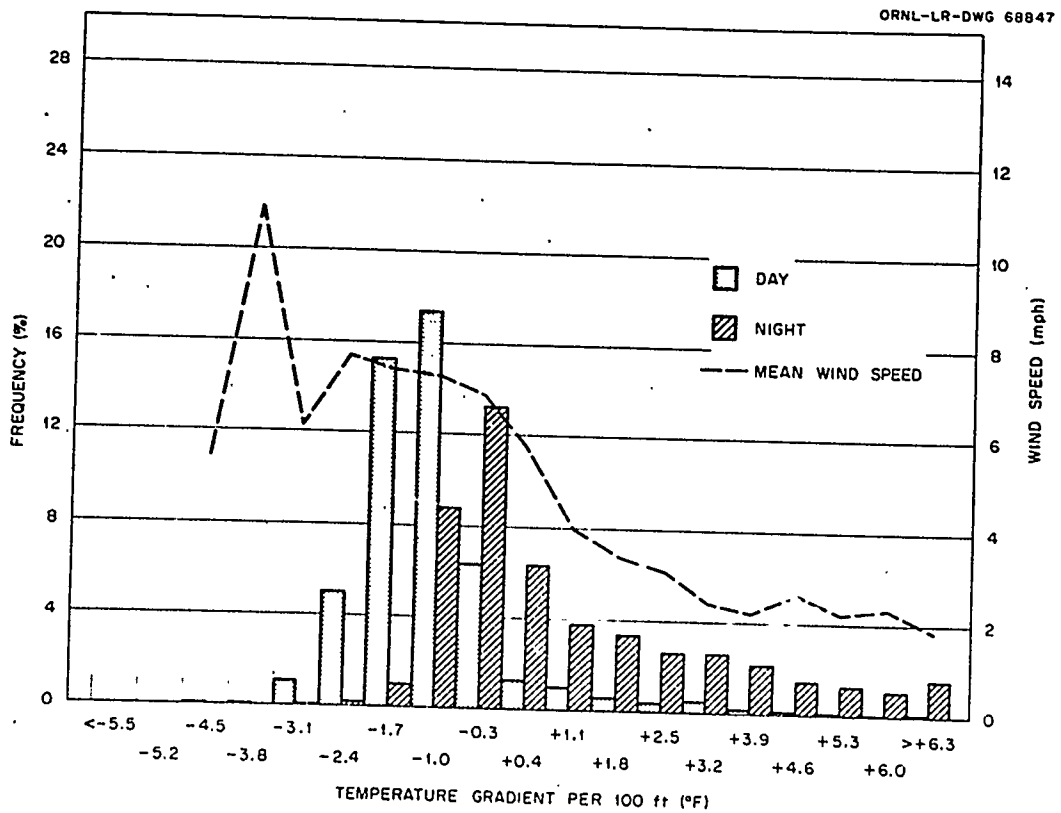
January, Day and Night Temperature Gradient Frequency with Mean Wind Speed.

FIGURE 33



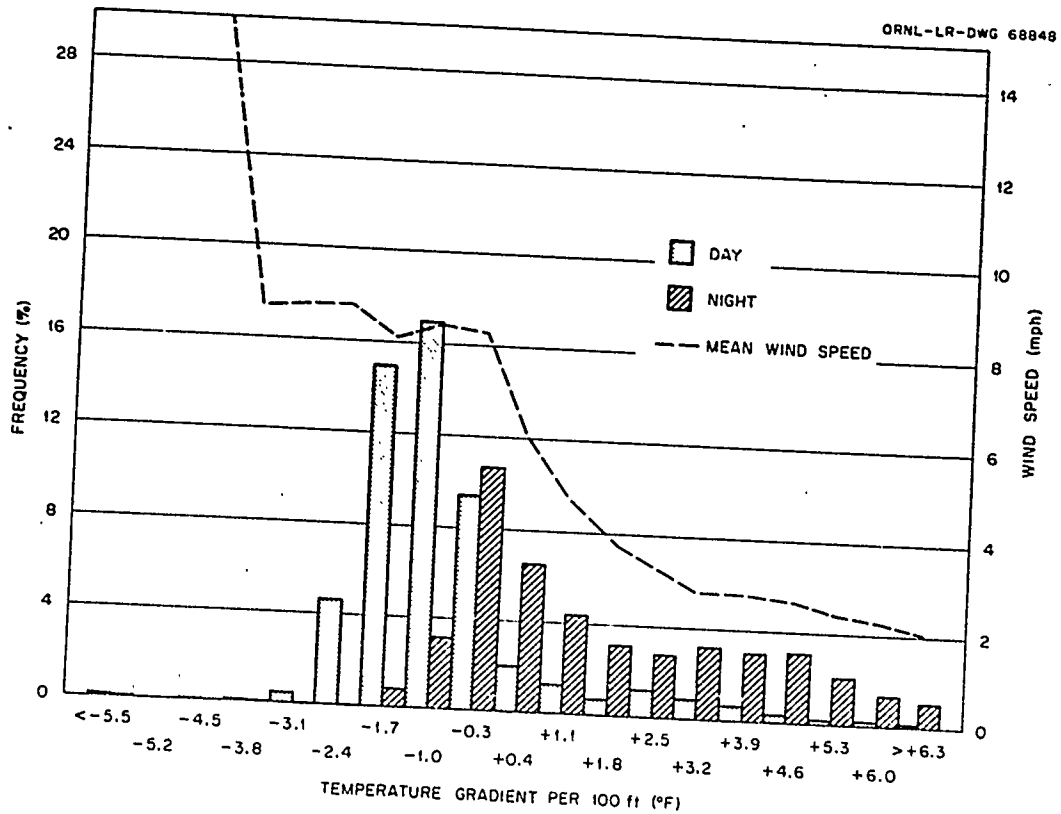
February, Day and Night Temperature Gradient Frequency with Mean Wind Speed.

FIGURE 34



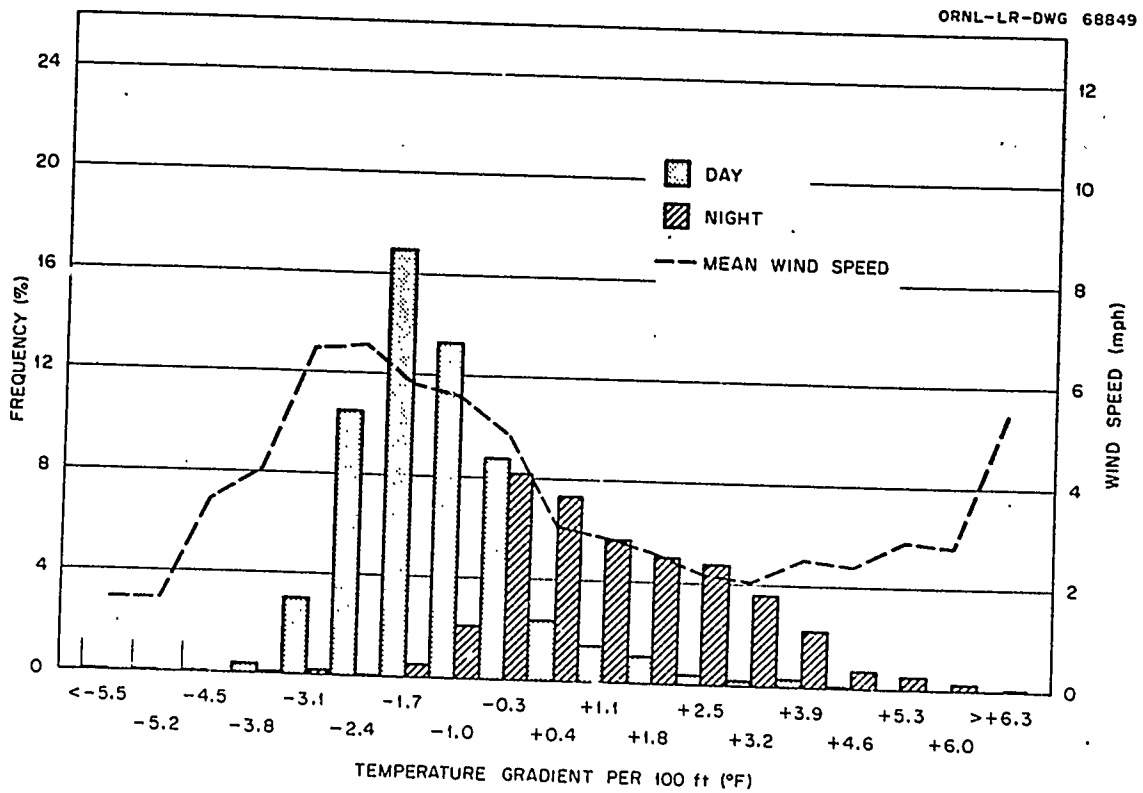
March, Day and Night Temperature Gradient Frequency with Mean Wind Speed.

FIGURE 35



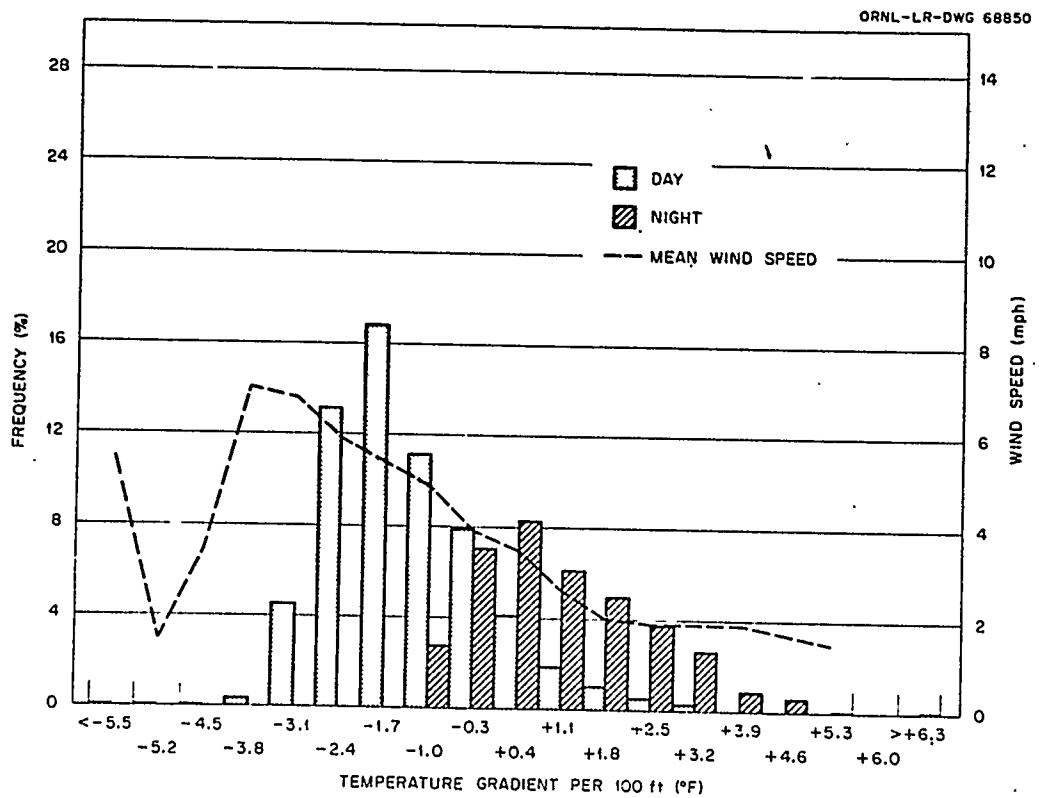
April, Day and Night Temperature Gradient Frequency with Mean Wind Speed.

FIGURE 36



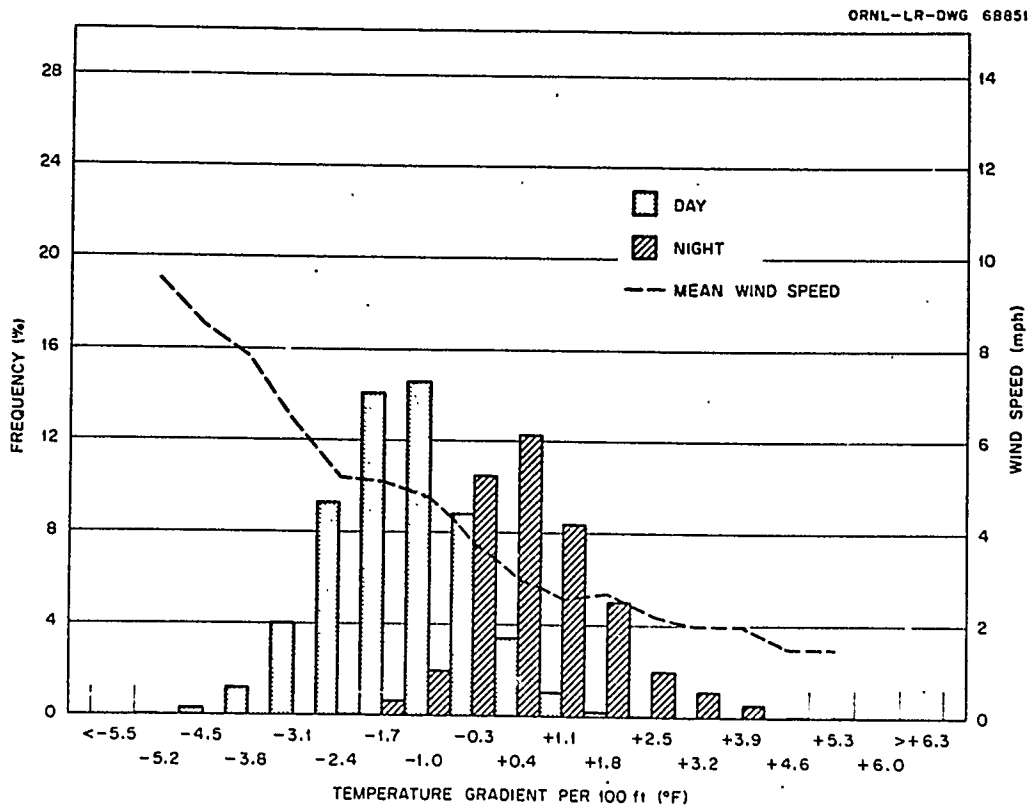
May, Day and Night Temperature Gradient Frequency with Mean Wind Speed.

FIGURE 37



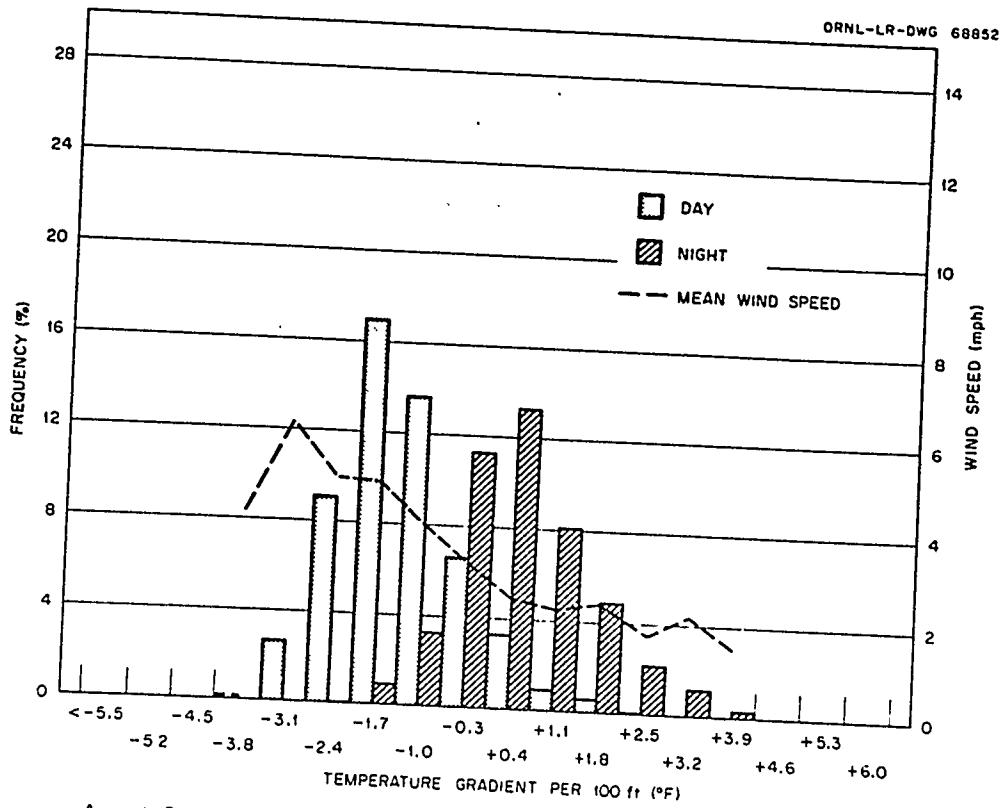
June, Day and Night Temperature Gradient Frequency with Mean Wind Speed.

FIGURE 38



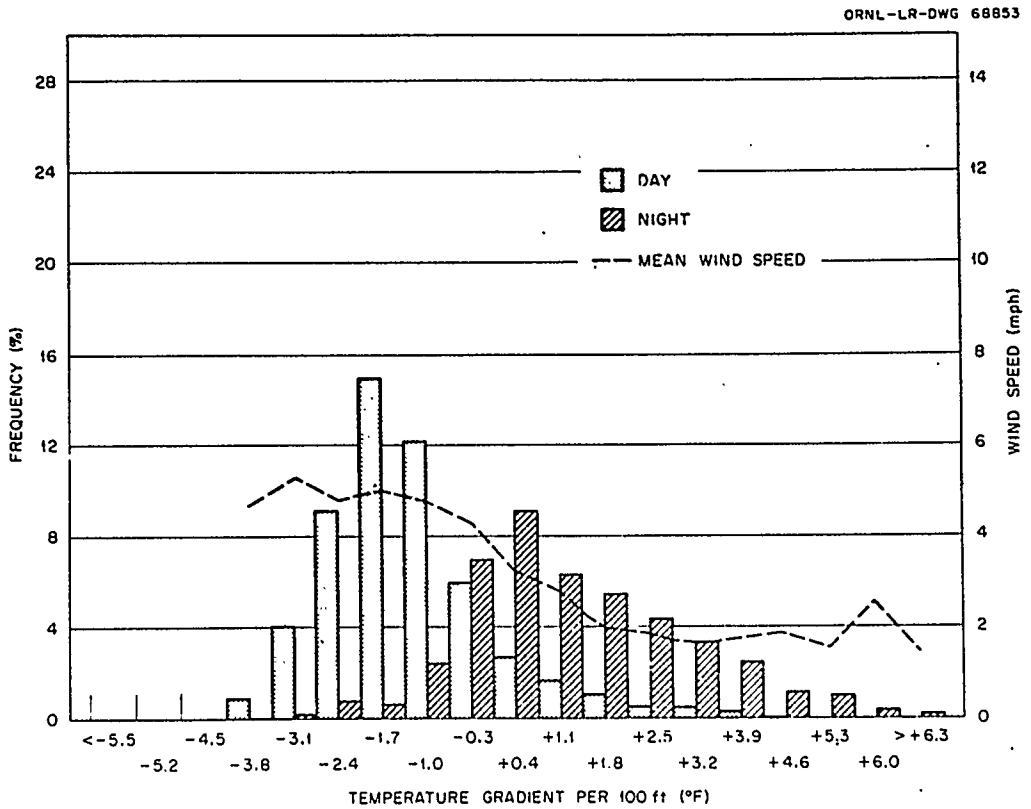
July, Day and Night Temperature Gradient Frequency with Mean Wind Speed.

FIGURE 39



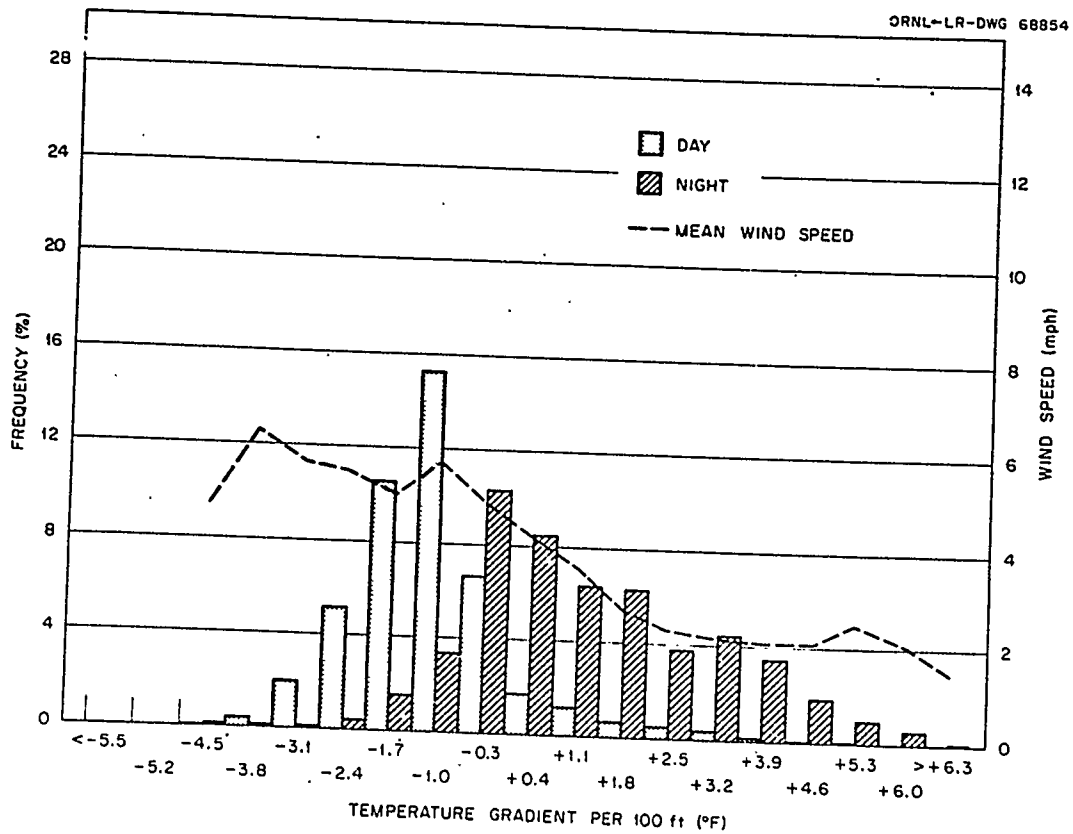
August, Day and Night Temperature Gradient Frequency with Mean Wind Speed.

FIGURE 40



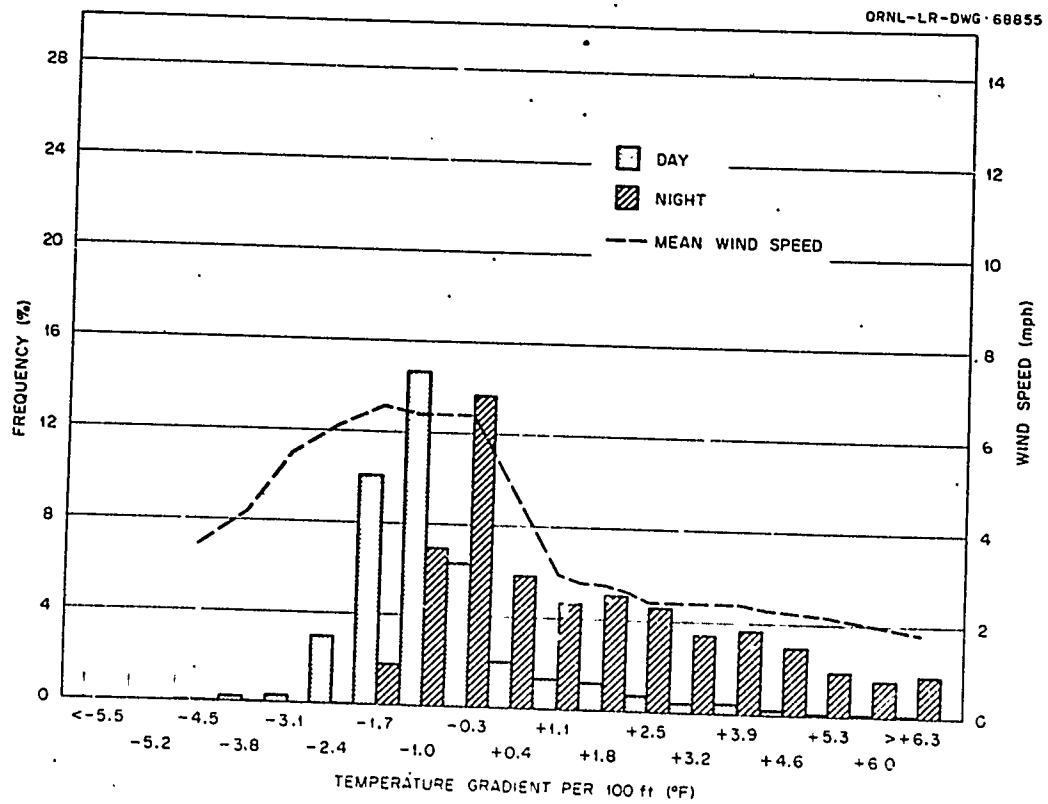
September, Day and Night Temperature Gradient Frequency with Mean Wind Speed.

FIGURE 11



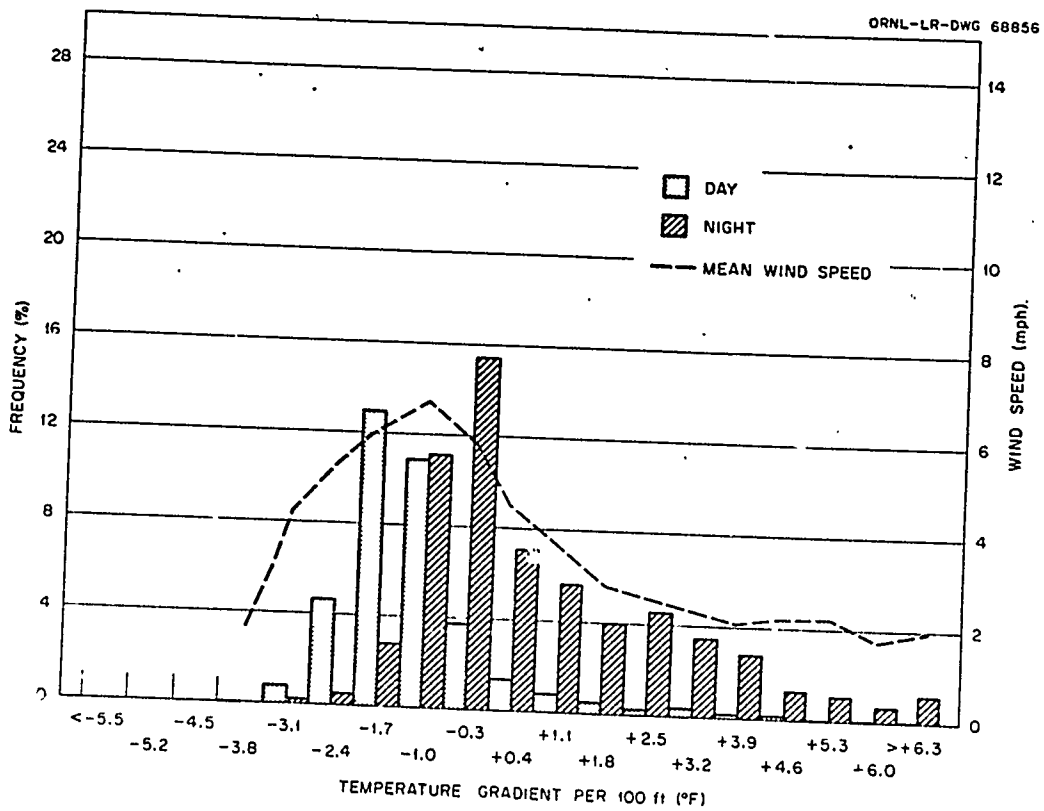
October, Day and Night Temperature Gradient Frequency with Mean Wind Speed.

FIGURE 12



November, Day and Night Temperature Gradient Frequency with Mean Wind Speed.

FIGURE 4.5

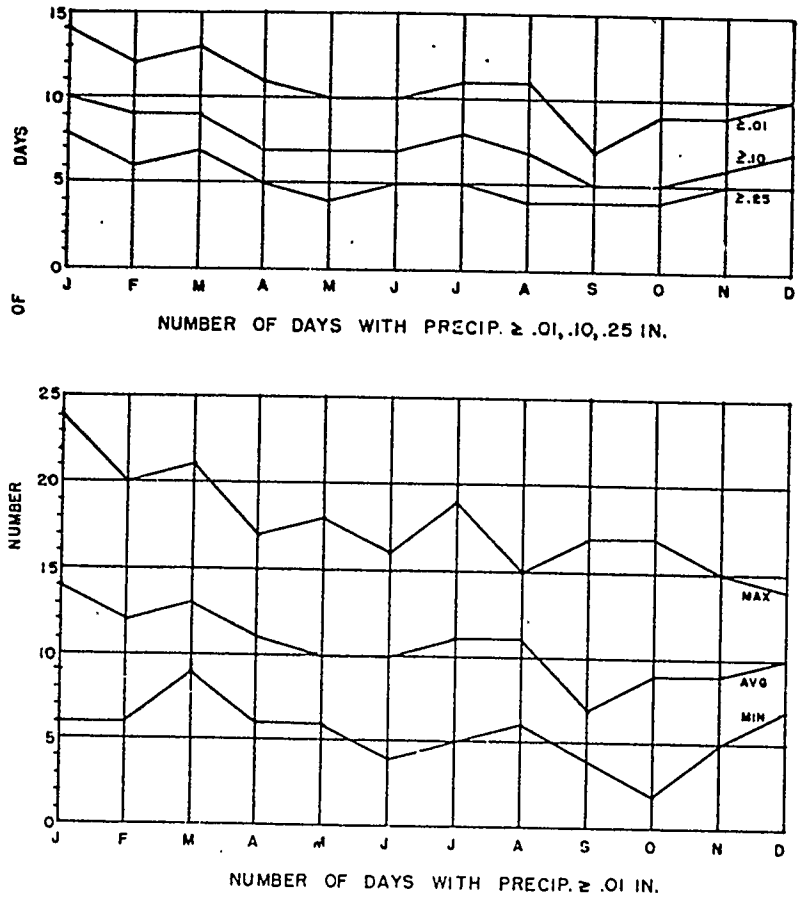


December, Day and Night Temperature Gradient Frequency with Mean Wind Speed.

FIGURE 14

AVERAGE MONTHLY FREQUENCY OF PRECIPITATION

TOWN



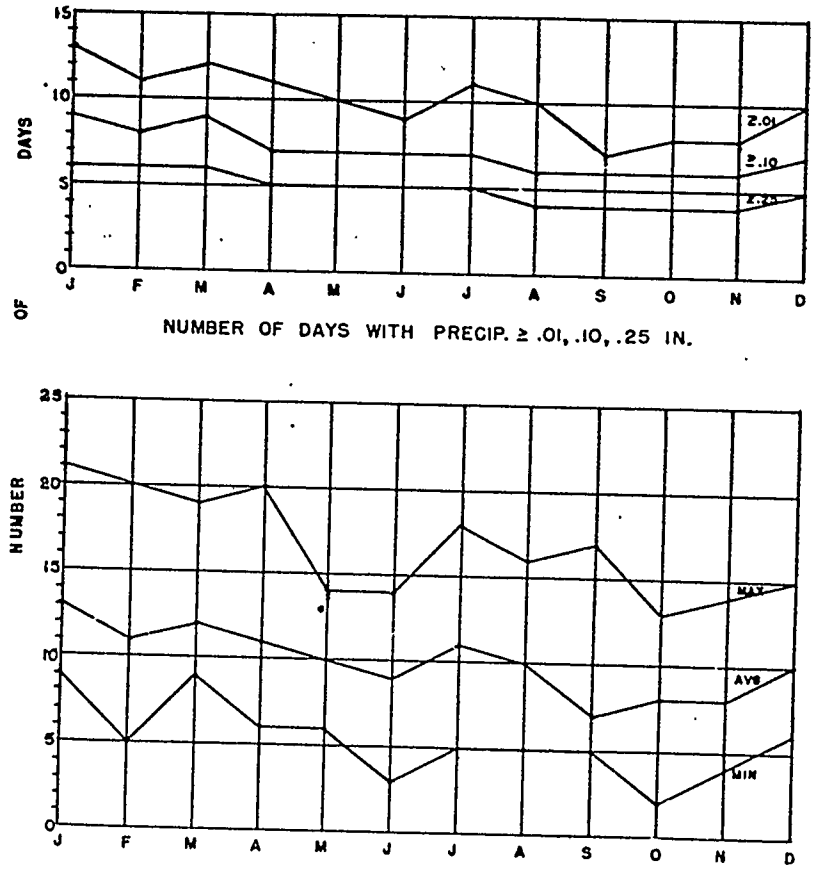
NUMBER OF DAYS WITH PRECIP. ≥ .01, .10, .25 IN.

NUMBER OF DAYS WITH PRECIP. ≥ .01 IN.

FIGURE 45

AVERAGE MONTHLY FREQUENCY OF PRECIPITATION

X-10



NUMBER OF DAYS WITH PRECIP. ≥ .01, .10, .25 IN.

NUMBER OF DAYS WITH PRECIP. ≥ .01 IN.

FIGURE 46

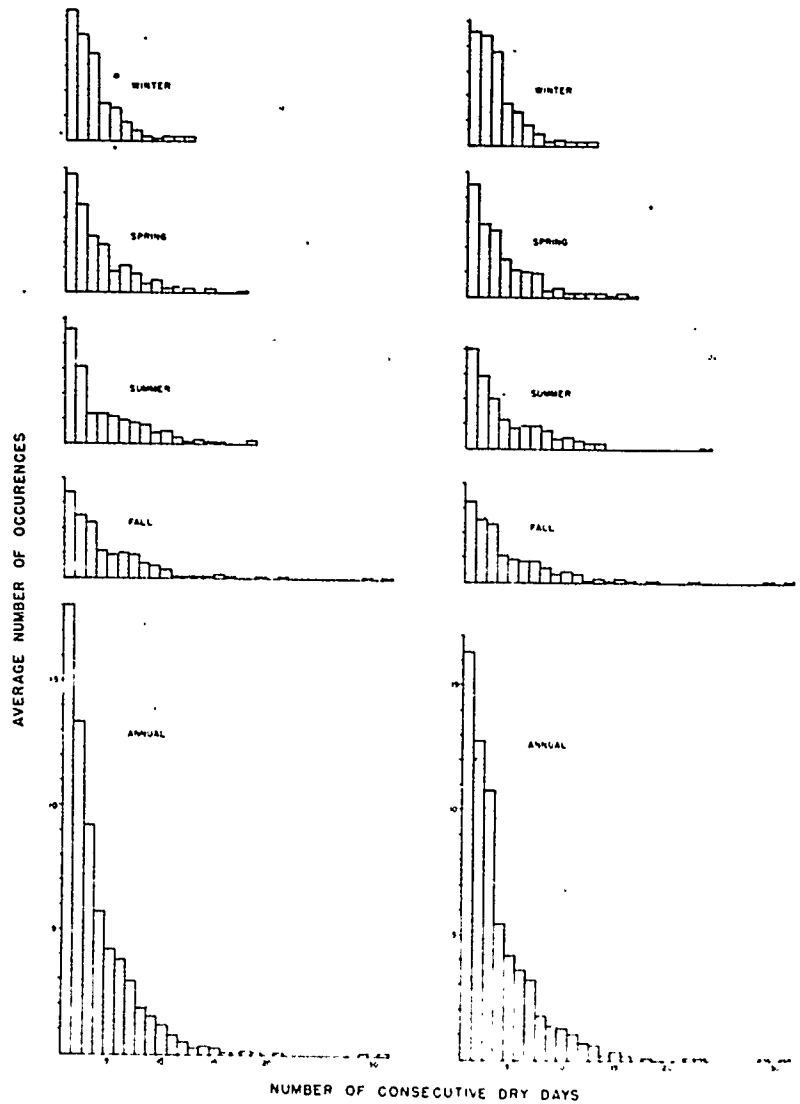

WINTER
SPRING
SUMMER
FALL
ANNUAL
WINTER
SPRING
SUMMER
FALL
ANNUAL
AVERAGE NUMBER OF OCCURENCES
NUMBER OF CONSECUTIVE DRY DAYS

FIGURE 47

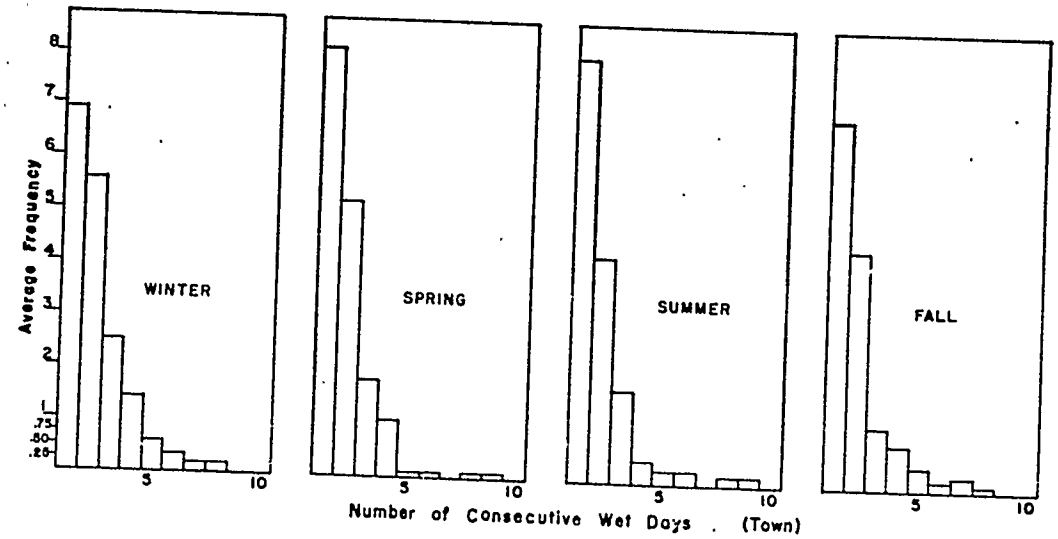


FIGURE 48

END