AV-R-93-08-200

Volume 1 of 2

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE (SITE) HISTORICAL DATA SUMMARY

Prepared for

EG&G Rocky Flats, Inc.
Air Quality Division
P.O. Box 464, Bldg. 030
Golden, Colorado 80204-0464

February 1995

1/84

ADMIN RECORD

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EG&G Rocky Flats, Inc.
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P.O. Box 464, Bldg. 030
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Prepared by

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February 1995

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Section 1

INTRODUCTION

1.1 OBJECTIVES AND BACKGROUND

AeroVironment Inc. was contracted by EG&G Rocky Flats, Inc. to screen, validate, analyze and graph the historical meteorological data collected at the Rocky Flats Environmental Technology Site (Site). This task was undertaken for the purpose of fulfilling requirements of the U.S. Department of Energy (DOE) and the U.S. Environmental Protection Agency (EPA) for safety and regulatory compliance.

The meteorological data have been collected primarily for the protection of the workers, the public and the environment. Additionally the data are used to assist general plant operations, engineering and construction activities and environmental studies. The following DOE directives govern how the meteorological data are collected and quality assured: DOE Order 5400.1, "General Environmental Protection Program" (1988), "Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance" (1991) and DOE Order 5500.3A, "Emergency Planning and Preparedness for Operational Emergencies" (1991).

In terms of environmental compliance, the meteorological data are used as inputs to dispersion models required by the Clean Air Act (CAA) and to support studies and clean up operations in accordance with the CAA and the National Emissions Standards for Hazardous Air Pollutants which requires the plant to limit emissions of radionuclides and beryllium. Precipitation data are collected and used to characterize surface water flow as required by the EPA.

1.2 HISTORICAL LOCATIONS OF WEATHER STATIONS AND DATA COLLECTED

The Site is located in the Rocky Mountain foothills between Arvada and Boulder (Figure 1.1). It is bounded by Indiana Street on the east, Colorado State Highways 128 on the north, 93 on the west and 72 to the south. The topography is rolling hills. The area is arid due to the shadow effect of the Rocky Mountains to the west.

Meteorological observations have been made at the Site since 1952 (Figure 1.2). The meteorological monitoring station was first established on the roof of Building 991. The original observations included temperature, relative humidity, precipitation, wind speed and wind direction. In January 1953, the monitoring station was moved to the roof of Building 123, where it remained until April 1975. The monitoring station was then moved to a 61-meter tower that was erected in the West Buffer Zone.

The coordinates and elevation of the West Buffer Zone location is: 39° 53' 4" north, 105° 12' 36" west and approximately 6150' above mean sea level. The locations of

FIGURE 1.1. Area map of Rocky Flats environmental technology Site and surrounding communities.

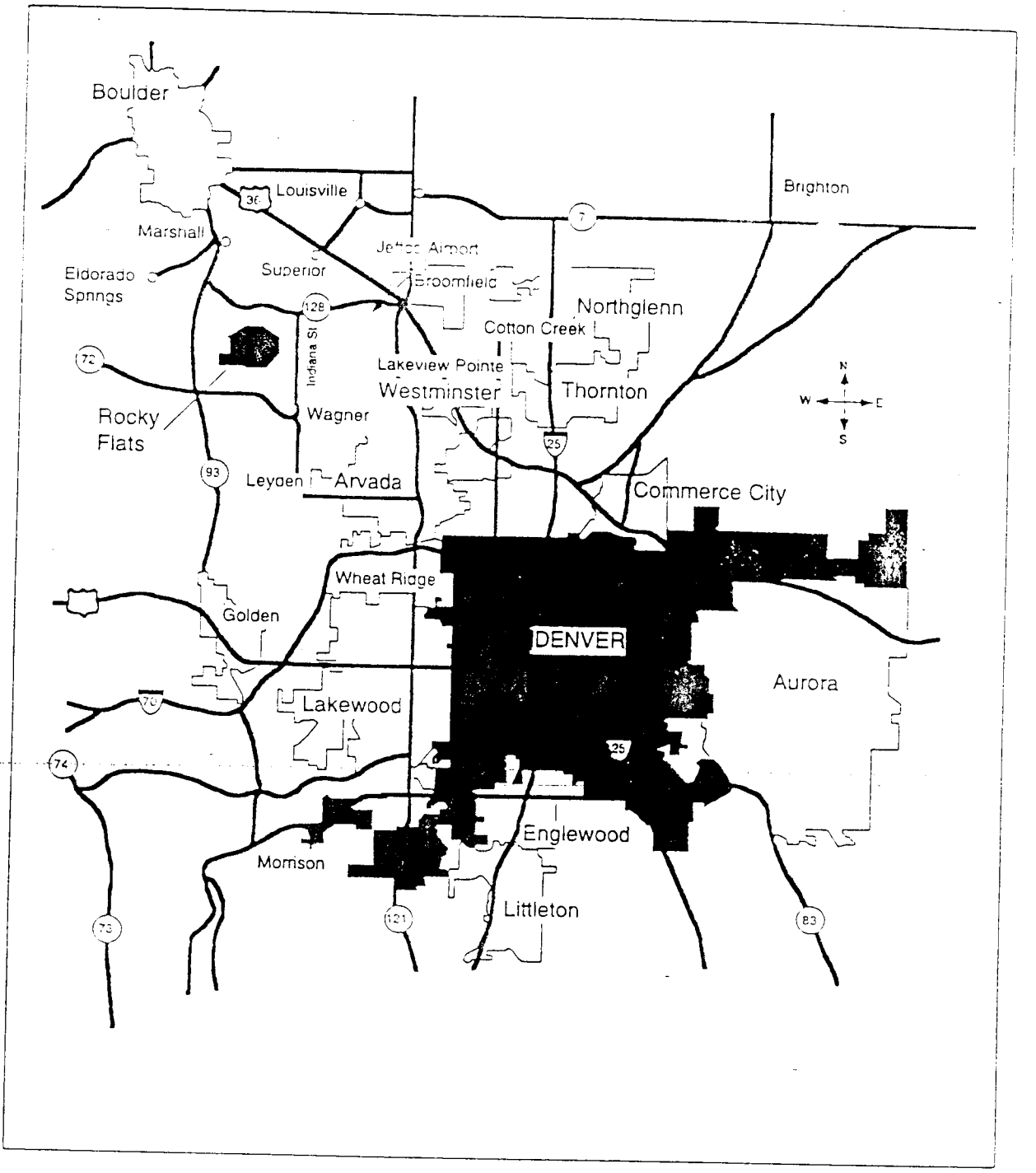
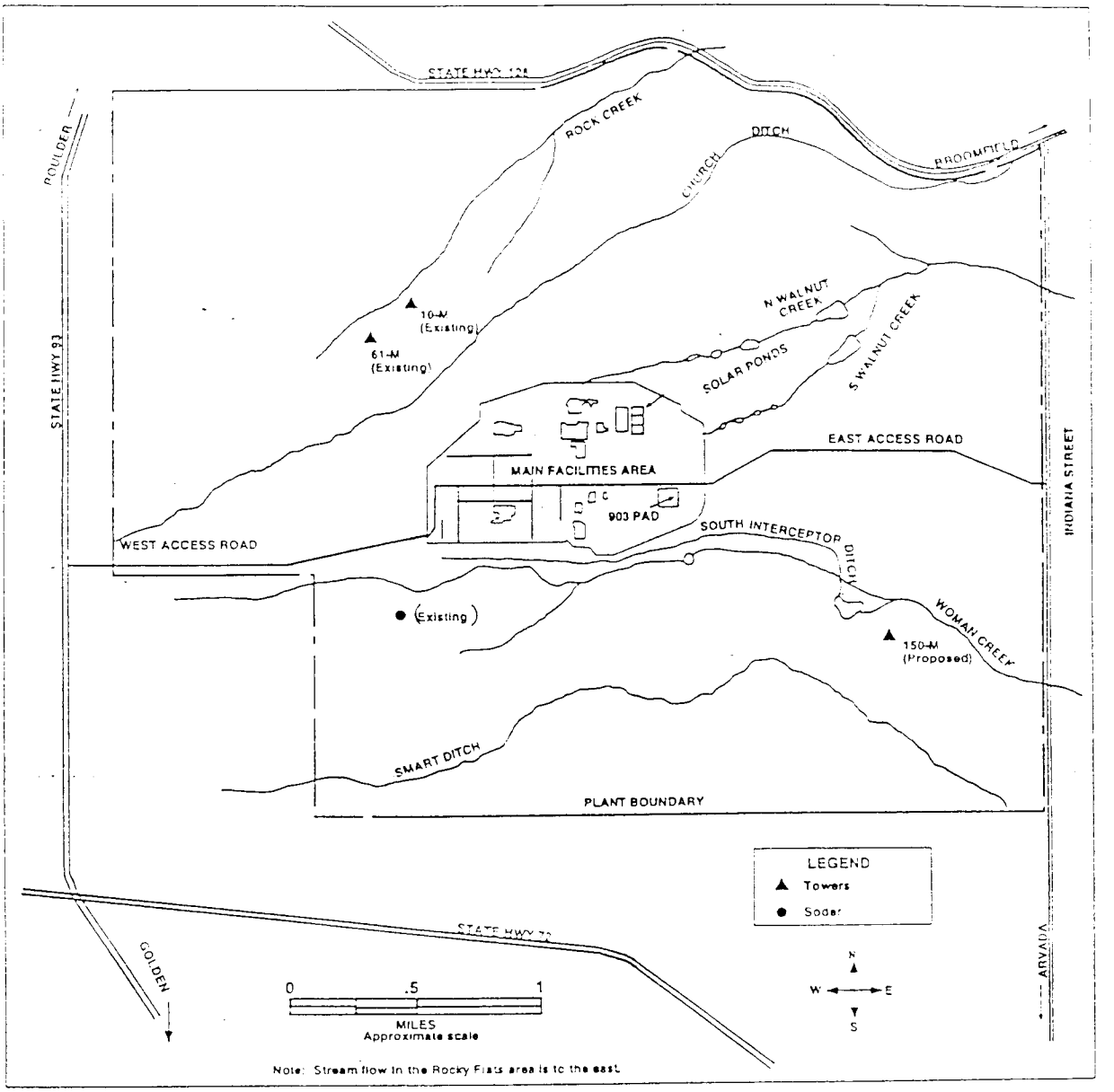


FIGURE 1.2. Existing and proposed meteorological monitoring network at Rocky Flats environmental technology Site.



Buildings 991, 123 and 771 with respect to the West Buffer Zone location are approximately 1.75 miles east, 1 mile east-southeast and 1.5 miles east, respectively.

Periodically, additional monitoring stations have been set up and operated in conjunction with various activities at the Rocky Flats facility. During 1975 to 1989, monitoring stations were set up and operated at Building 881, a utility pole at the East Gate, and a wind test site in the northwest corner of the facility. In 1989, a 10-meter tower was erected and instrumented about 50 meters northeast of the 61-meter tower. This tower and associated instrumentation were set up as a redundant system to the 61-meter tower to serve as a backup during possible emergencies. A pair of wind sensors were set up at Building 881 during 1991 to support remediation activities. Because of siting requirements which put the sensors at near-ground levels and near obstructions, the data are only representative of a very local area.

The data collected through April 1975 consisted of temperature, relative humidity, precipitation, wind speed and wind direction. These data were recorded manually in a logbook and represent instantaneous readings taken within five minutes before each hour. With the move to the present West Buffer Zone location in May 1975, multilevel measurements of wind and temperature (10, 25 and 60 meters) were added along with single level measurements of solar radiation, barometric pressure, soil temperature, soil heat flux and absolute humidity (see Figure 1.3 and Table 1.1). Measurements have continued at this location until the present, but for unknown reasons the data collected between March 1977 and December 1983 were lost. Tower data recorded on strip charts from 1984 through early 1989 were digitized, but until recently were not validated or analyzed. Much of the data (1984 to early 1989) have large gaps and questionable quality. Starting in early 1989, the data have been collected by a digital data logger. Data collected through 1991 are also of questionable quality. Starting in 1992, the data have been routinely validated in accordance with an established quality assurance (QA) program that specifies how the data are archived, screened, corrected and reviewed.

1.3 DATA USED IN THIS ANALYSIS

1.3.1 Data Sets

The meteorological data used in these analyses were collected by the primary meteorological monitoring station located at Building 123 from January 1953 to March 1975 and in the West Buffer Zone after March 1975, as well as precipitation data collected between July 1976 and September 1988 at Building 771.

The data from the first year of operation (1952) collected at the Building 991 location were not available for this analysis. Annual paper summaries for the data collected at the Building 123 and West Buffer Zone locations between January 1953 and February 1977 provided all the data used in this analysis up through December 1963 and supplemented other data available through the end of this period. Each of these annual summaries included:

FIGURE 1.3. Meteorological monitoring tower configuration.

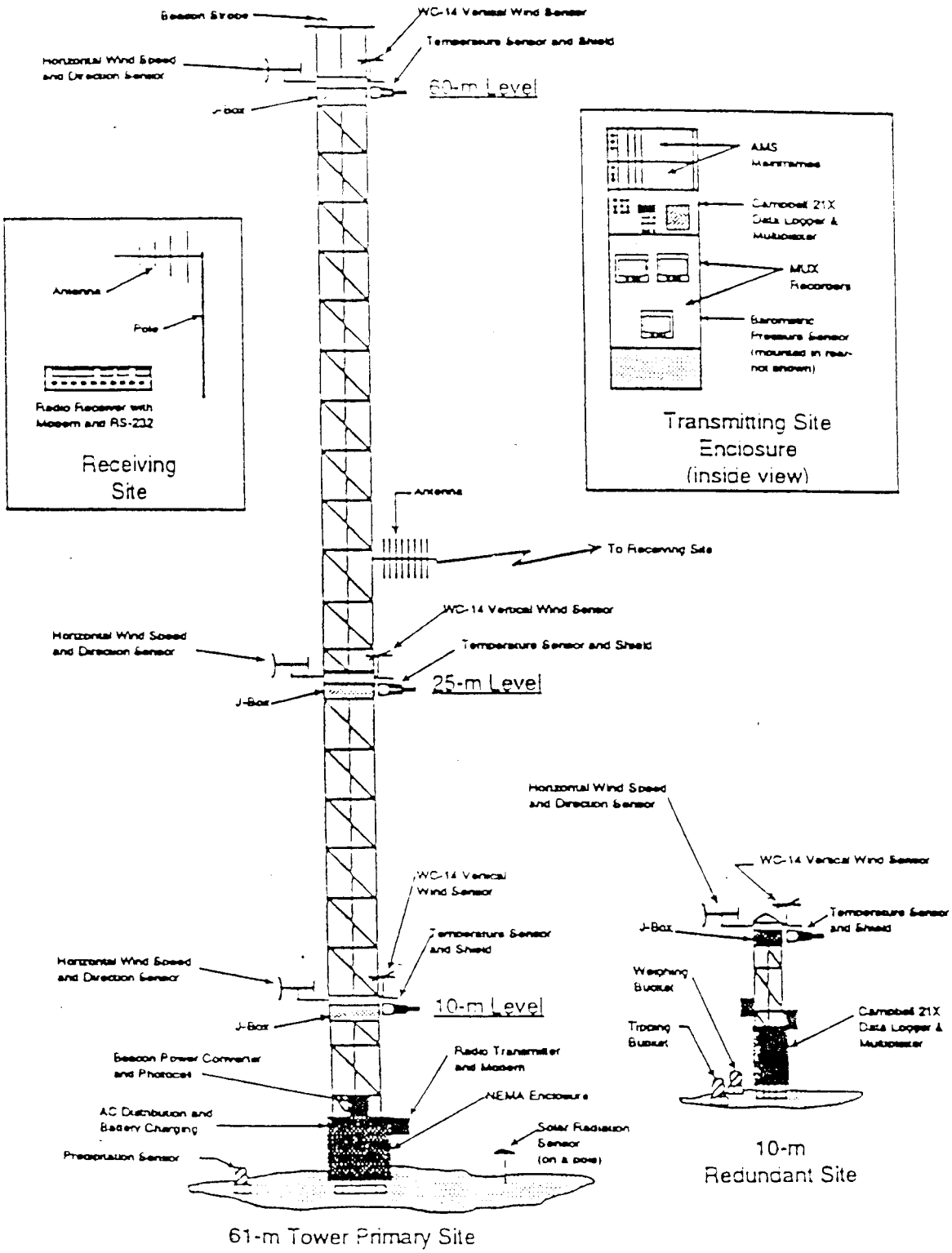


TABLE 1.1. Meteorological monitoring equipment specifications at Rocky Flats environmental technology Site.

PARAMETER	MEASUREMENT PRINCIPAL	MANUFACTURER	MODEL NO.	RANGE
61M Tower Horiz. Wind Speed *	Photochopper w/Cups	Climatronics	100075	0 – 55.9 m/sec
61M Tower Wind Direction *	Phase Resolver w/Vane	Climatronics.	102139	0 - 360 degrees
10M Tower Horiz. Wind Speed *+	DC Tachometer w/Propeller	RM Young Co.	05035	0 - 50 m/sec
10M Tower Wind Direction *+	Potentiometer w/Vane	RM Young Co.	05035	0 - 355 degrees
Vertical Wind Speed *+	DC Tachometer w/Propeller	Gill	27106	-9.9 to 9.9 m/sec
61M Tower Ambient Air Temperature *	Thermistor Radiation Shield	Climatronics	100093 TS-10	-30 to 50 deg C NA
10M Tower Ambient Air Temperature *+	Thermistor Radiation Shield	Campbell Gill 8-Plate	207 NA	-50 to 50 deg C NA
Fast Response Temperature *	Thermistor Radiation Shield	Climatronics	100093-3 TS-10	-30 to 50 deg C NA
Relative Humidity *	Capacitance Hygrometer	Rotronics	MP100	0 - 100%
Solar Radiation *	Black and White Pyranometer	Eppley	8-48	0 - 1400 Watts/m^2
Infrared (Longwave) Radiation *	Silicon Pyrgeometer	Eppley	PIR	0 - 500 Watts/m^2
Precipitation *+	Tipping Bucket Gage (8")	Novalynx	260-312/250E-12	NA
Precipitation *	Tipping Bucket Gage (6")	Climatronics	BWS	NA
Precipitation +	Weighing Bucket Gage (12)	Belfort	5-780-300MM	NA
Barometric Pressure *	Ceramic Capacitance	Setra Systems	270	600 - 1100 millibars
Soil Heat Flux *	Thermopile	Weathermeasure	3983	+/- 1500 Watts/u^2
Absolute Humidity *	Optical Hygrometer	Ophir Corp.	2000	0 - 50 g/m^3
Soil Temperature *	Thermistor	Campbell	107	-35 to 50 deg C

* 61-meter tower
\+ 10-meter tower

- Mean annual temperature
- Maximum annual temperature
- Minimum annual temperature
- Average annual relative humidity
- Total annual precipitation
- Greatest amount of precipitation in a single day
- Greatest depth of snowfall in a single day
- Greatest monthly mean wind speed
- Mean annual wind velocity
- Peak annual gust velocity
- Predominant annual wind direction

and graphs of:

- Monthly maximum temperature
- Mean monthly temperature
- Monthly minimum temperature
- Average monthly maximum temperature
- Average monthly minimum temperature
- Monthly heating degree days based on 65oF
- Average monthly relative humidity
- Monthly precipitation totals

From January 1964 until February 1977, monthly climatic summaries in addition to the annual summaries were provided in Excel spreadsheet format. The information provided by each of these monthly summaries was:

- Daily maximum temperature
- Daily minimum temperature
- Daily mean temperature
- Mean daily dew-point temperature
- Mean daily wind speed
- Daily maximum instantaneous wind speed
- Total daily precipitation
- Mean daily barometric pressure
- Total daily solar radiation (May 1975 to December 1993)

The 1984 through early 1989 data were originally collected on strip charts but later digitized. A digital data logger was used to collect the data after this period as one-second data. Fifteen-minute averages, maximums and minimums for each 15-minute period were calculated from these data for the entire period as follows:

- Average wind speed at 10, 25 and 61 meters
- Maximum wind speed at 10, 25 and 61 meters
- Minimum wind speed at 10, 25 and 61 meters
- Average wind direction at 10, 25 and 61 meters

- Standard deviation of the horizontal wind speed at 10, 25 and 61 meters
- Standard deviation of the wind direction at 10, 25 and 61 meters
- Average vertical wind speed at 10, 25 and 61 meters
- Maximum vertical wind speed at 10, 25 and 61 meters
- Minimum vertical wind speed at 10, 25 and 61 meters
- Standard deviation of the vertical wind speed at 10, 25 and 61 meters
- Average temperature at 10, 25 and 61 meters
- Maximum temperature at 10, 25 and 61 meters
- Minimum temperature at 10, 25 and 61 meters
- Average dew-point temperature at 10 meters
- Total precipitation
- Average solar radiation
- Maximum solar radiation
- Minimum solar radiation

1.3.2 Data Quality

o Temperature

The mean temperatures for the Building 123 and West Buffer Zone locations were almost identical. Differences were noted in the average maximum and average minimum temperatures. The range of the Building 123 average extreme temperature data was larger than the equivalent West Buffer Zone data probably because of the radiative effects of the Building 123 rooftop.

o Relative Humidity

The average annual relative humidity data differed between the Building 123 and West Buffer Zone by approximately 18%.

o Wind

The average annual wind speeds for the two locations (Building 123 and the West Buffer Zone) differed by approximately 19%. The differences are due to the difference in the roughness lengths of the two sites. The West Buffer Zone is open and flat with a roughness length on the order of centimeters. The area surrounding Building 123, on the other hand, is the area of highest building density at the Site. The buildings that surround Building 123 act to slow the wind.

The yearly and monthly maximum wind speeds differ in how they were reported for the two locations. The Building 123 maximum wind data were reported as maximum wind gusts, which according to U.S. weather observing practices, are reported when the peak wind speed reaches at least 16 knots and the variation in wind speed between the peaks and the lulls is at least 9 knots. The digitized and digital data collected at the West Buffer Zone location reports the maximum wind speeds for each 15-minute averaging period from the one-second data. It is believed that the wind gust data

collected before May 1975 is actually maximum wind speeds. For these analyses, all data were treated as maximum wind speeds and averaged together accordingly.

- **Insolation**

The monthly insolation averages were low as evidenced by the calculations for percent possible monthly insolation (Table 2.32). In this analysis, the percent possible monthly insolation decreases between January and August and increases between August and December. Data quality is the underlying reason for this counter intuitive result since the averages are based on incomplete data sets and data of questionable quality.

- Precipitation

Years 1984-1986 were eliminated from all precipitation calculations. Data collected during these years did not encompass the entire year. Inclusion of this partial data in the analyses would have skewed the results.

1.4 DATA VALIDATION PROCEDURES

Data validation was performed by AeroVironment for the 1984-1993 data set only. The 1984 to 1989 data were collected on strip charts and digitized. The data since 1989 were collected electronically and processed into 15-minute averages at the time of data collection. Because these data were available in electronic form, it was possible to run these data through screening programs that checked statistically for rates of change and meteorological representativeness. Due to the scarcity of quality control (QC) data, most of the data validation was performed by graphing the data and looking for outliers and patterns that did not fit known meteorological and physical patterns. In many cases it was not possible to decide whether the outlier or anomaly was real or bad data. Much of these data were left in the data base by agreement between the contracting officer and AeroVironment.

The 1953-1976 data set was provided in the form of paper annual summaries without supporting QC data. Likewise, the 1964-1977 data set was supplied as monthly summaries in Excel spreadsheet format without supporting QC data. An attempt was made to secure Local Climatological Data summaries and Daily Weather Maps from both the National Climatic Data Center in Ashville, North Carolina, and the Colorado State Meteorologist in order to make comparisons with either data collected at nearby monitoring sites or the large-scale meteorological flow patterns. This attempt ultimately failed due to the unavailability of these data at the local level and the high cost and long lead time required to secure these data on the National level.

1.4.1 1953 to 1977

The data collected during this period were not validated by AeroVironment. The data were provided without supporting QC data, which made it impossible to make the necessary comparisons. Time and budget constraints made it necessary to include these data as they were.

1.4.2 1984 to 1993

AeroVironment validated the data collected during this period. The monitoring station location during this period was the West Buffer Zone. The procedures used in the validation process were:

- The data were provided to AV on 90-megabyte (MB) Bernoulli disks (for MS DOS) along with all audit and service records that were used in the validation procedures.

- The data were uploaded to the AV computer and automatically loaded into the database (MicroSoft Access). Members of the data validation team did random checks of the loaded data against the digital data to ensure accurate data loading. Once the data loading had been verified, the percentage of values for data capture of the raw data were calculated. This information was then compared against the validated data base after all data edits and corrections had been performed.

- Once the loading of the data was completed, a preliminary screening routine was run. This screening checked the values for outliers (i.e., data greater than or less than specified values) and maximum and minimum rates of change between adjacent observations (i.e., values changing more or less than specific amounts between readings). An example of a "flagged" output of hourly data designed and used by AV is shown in Figure 1.4. Data that do not pass the outlier or rate of change tests were flagged by the computer for further investigation. The computer also screened the data for consistency between the various levels on the tower. For example, changes in wind speed between vertical levels (i.e., wind shear) which exceeded a specified amount were flagged for further investigation. Lapse rates were also calculated between levels to check for consistency and reasonableness (e.g., an auto-convective lapse rate would have been flagged for additional validation).

- Next, time-series plots of the data were generated and inspected by a meteorologist in order to determine periods of questionable data, occurrences of anomalous events, and any interesting patterns. An example of a time-series plot generated by AV is shown in Figure 1.5. As a cross check, local climatological data (from NOAA) was obtained to determine if the data from the tower were reasonable and within expected ranges for the geographical area. Additionally, Site audit and service records were used to construct a station instrumentation "history" for all variables at each level on the tower. This history was used to determine periods of bad and/or questionable instrument response.

Our team of meteorologists examined all of the above data and data products and determined which periods were valid and which were questionable. All periods of known instrument problems were marked for invalidation from the data base. Initially,

FIGURE 1.4. An example of a screened data output used in data validations.

TEMPERATURE [62101]

DEGREES CENTIGRADE
LEVEL HEIGHT 10 METERS

NATIONAL PARK SERVICE GASEOUS POLLUTANT NETWORK. #1

SITE 34 GREAT SMOKY MTNS. NP - LOOK ROCK, TN

APR. 1993

AEROVIRONMENT INC.

RAW DATA
AS OF 18/MAY/93

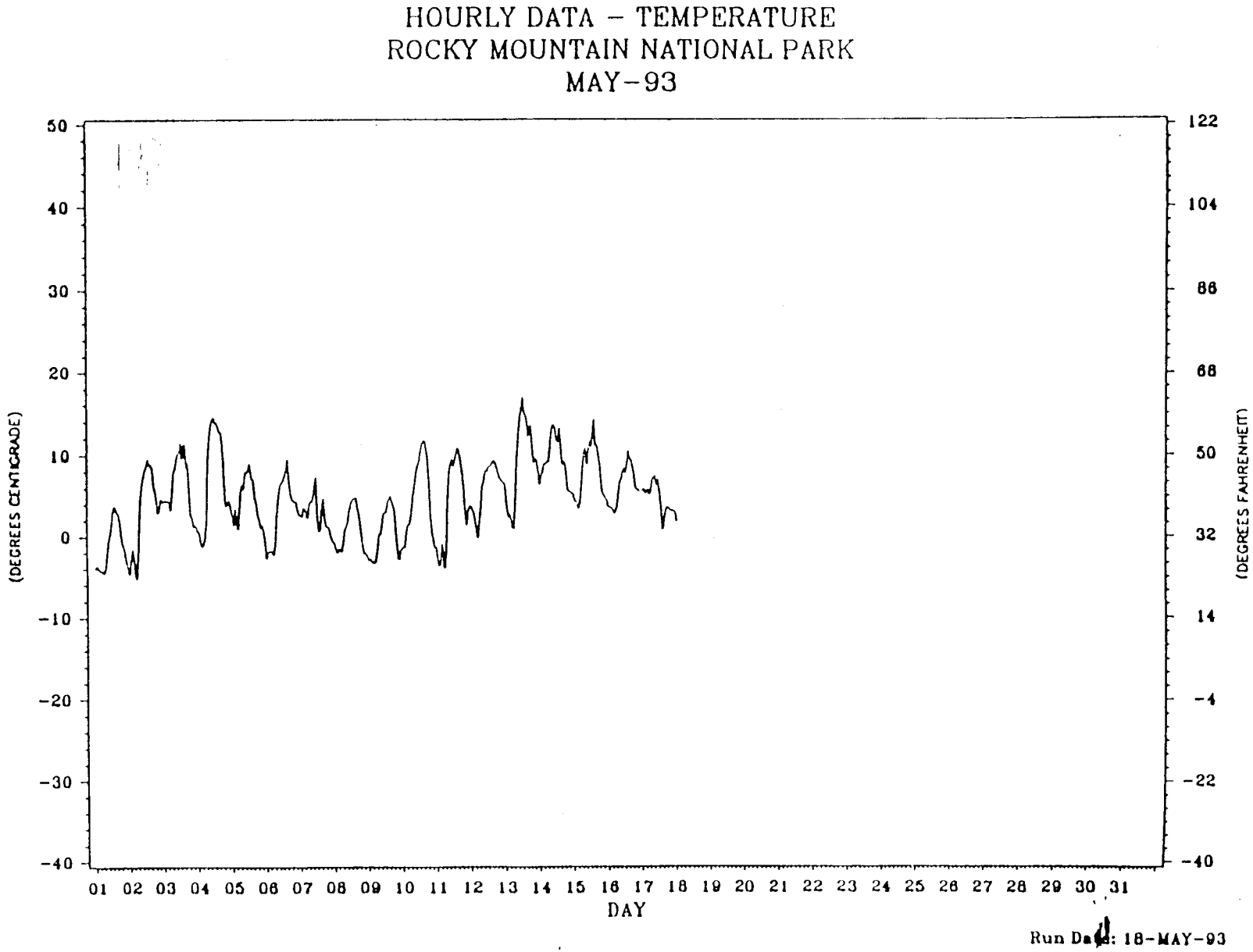
CLOCK HOUR [LOCAL STANDARD TIME]

DY	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	MIN	MAX
1	11.5	10.1	9.4	8.9	8.4	7.9	7.3	7.2	7.3	7.8	7.7	8.2	8.5	8.3	8.3	7.5	6.1	5.4	5.0	4.2	3.9	3.6	3.0	2.9	2.9	11.5
2*	2.8	2.3	1.2*	0.6*	0.2*	0.7*	1.2*	1.5*	1.8*	2.1*	2.2*	2.3*	2.2*	2.0*	1.6*	1.5*	1.3*	1.4*	1.5*	1.6*	1.8*	1.8*	1.9*	2.0	-2.3	2.8
3-	2.1*	2.2*	2.2*	2.2*	2.4*	2.7*	2.9*	2.3*	1.4*	0.1*	1.8*	4.2	5.3	[PF]	[PF]	[PF]	[PF]	9.0	8.0	7.4	7.1	6.7	6.6	6.5	-2.9	9.0
4	6.6	6.4	6.2	5.9	6.7	5.5	5.2	5.5	7.8	8.3	7.7	9.4	9.9	9.7	9.9	10.3	9.3	9.3	8.7	6.6	5.5	5.1	5.1	5.8	5.1	10.3
5	5.8	5.9	5.7	5.6	5.3	5.3	5.4	6.1	6.3	6.6	8.4	7.4	6.9	7.4	7.7	7.4	7.3	7.0	6.7	6.6	6.7	6.2	6.5	5.7	5.3	8.4
6	5.8	5.5	5.2	5.5	5.6	5.3	5.0	5.0	4.9	5.1	5.7	6.1	6.3	6.5	7.1	7.3	7.7	7.5	7.5	7.5	7.6	7.3	7.4	7.4	4.9	7.7
7	6.7	7.3	7.8	8.0	8.0	7.8	7.2	7.8	8.0	9.5	9.6	11.6	12.9	13.2	14.0	15.3	15.5	15.0	13.8	12.9	12.3	12.7	12.6	12.0	6.7	15.5
8	11.3	11.2	10.8	10.5	10.3	9.5	8.2	10.2	11.5	14.3	14.7	17.4	17.1	16.1	15.8	16.7	17.0	16.5	15.8	15.3	14.5	13.7	13.6	13.6	9.2	17.4
9	13.4	12.8	12.2	12.0	11.7	11.7	12.0	11.6	12.4	12.8	11.6	9.6	9.2	9.8	10.0	10.3	10.4	11.0	10.8	10.1	9.1	7.7	7.5	7.2	7.2	13.4
10	6.8	6.5	5.8	5.5	5.3	5.0	4.8	4.6	5.0	5.8	7.3	8.7	10.2	11.5	12.6	13.8	14.5	14.5	13.7	12.4	12.2	12.0	11.8	11.6	4.6	14.5
11	11.7	11.9	11.6	11.7	12.1	12.0	12.1	13.2	14.7	16.1	17.9	19.4	20.7	21.6	19.8	21.4	22.1	21.5	19.9	18.7	17.6	17.1	16.0	15.0	11.6	22.1
12	14.2	13.9	14.0	13.6	13.5	13.2	12.6	12.4	13.8	14.7	15.7	16.8	17.6	18.4	18.1	19.0	19.9	19.6	18.9	18.4	18.4	16.9	16.2	16.0	12.4	19.9
13	15.7	16.0	14.8	14.8	15.6	15.1	14.6	15.1	16.0	18.3	17.2	18.0	19.0	19.9	20.7	20.9	21.3	20.8	20.1	19.8	19.6	19.1	18.8	18.7	14.6	21.3
14*	18.5	18.0	17.5	16.5	16.0	15.4	15.9	16.2	17.5	19.2	20.4	22.1	24.3	25.7*	26.3*	26.3*	25.9*	24.1	22.0	20.7	19.7	19.3	19.2	19.1	15.4	26.3
15	18.8	18.5	18.3	18.2	17.9	17.4	17.2	17.3	17.2	18.0	19.1	19.8	17.1	14.9	16.9	18.3	19.1	18.4	17.1	13.5	10.1	10.7	10.9	9.9	9.5	19.8
16*	8.4	6.7	5.5	5.4	5.0	4.7	4.6	4.7	4.5	4.6	4.9	6.4	7.0	6.3	6.2	6.1	5.9	5.6	4.7	4.8	4.4	2.9	1.6*	1.1*	1.1	8.4
17*	1.8*	2.2	2.3	2.2	2.1	1.7*	1.1*	1.7*	2.3	3.0	3.8	5.1	7.0	8.3	9.7	10.6	11.3	11.4	10.4	9.7	9.3	8.9	8.5	8.4	1.1	11.4
18	8.1	7.8	7.4	7.3	6.7	7.0	7.5	8.3	10.0	10.3	11.8	12.4	13.4	14.3	13.0	13.7	13.8	13.5	14.3	13.1	13.2	12.8	12.1	11.4	6.7	15.8
19	10.9	10.9	11.0	10.5	10.2	10.3	10.6	11.6	12.9	15.2	17.1	18.6	19.8	20.7	21.0	20.7	20.2	19.2	17.9	16.9	16.3	15.9	15.5	15.2	10.2	21.0
20	15.0	14.8	14.7	14.4	13.8	13.3	13.5	14.1	15.3	16.7	18.0	19.1	18.6	19.2	19.3	19.4	12.3	12.3	12.0	11.6	11.8	11.8	11.4	11.4	11.4	19.3
21*	11.3	10.9	7.4	6.4	6.4	6.3	6.1	6.3	6.1	4.2	3.7	4.0	3.6	3.3	2.0	0.9*	0.8*	0.4*	0.2*	0.1*	0.1*	0.2*	0.3*	0.8	-0.8	11.3
22-	0.9*	0.9*	0.9*	0.9*	0.9*	1.0*	0.9*	0.7*	0.2*	1.6*	3.2	4.8	5.8	7.1	8.0	8.6	8.9	9.3	8.3	7.0	6.9	6.5	6.1	5.9	-1.0	9.3
23	5.5	6.0	5.7	5.9	5.8	6.1	6.0	7.1	8.7	9.3	10.4	11.8	12.9	14.5	15.2	15.4	15.7	15.3	14.5	13.5	13.1	13.0	12.3	12.9	5.5	15.7
24	12.1	11.1	11.4	11.8	12.8	12.2	11.6	12.1	13.3	14.9	17.8	19.2	21.3	21.8	20.3	20.0	20.5	20.7	18.9	17.9	17.1	16.4	16.0	15.7	11.1	21.8
25	15.5	15.4	15.3	14.9	14.0	13.1	13.1	13.8	16.3	17.4	19.8	21.9	23.5	24.5	25.0	24.5	22.9	21.4	19.1	14.8	13.5	12.5	11.8	11.2	11.2	25.0
26*	11.1	11.0	10.7	10.8	11.1	10.6	10.0	9.5	9.2	9.0	8.7	7.6	9.8	10.5-	33.5*	16.6*	13.0*	12.9	13.2	11.2	10.6	10.0	9.3	8.6	-33.5	13.2
27	7.5	6.5	6.1	5.8	6.0	5.8	5.5	6.3	7.7	9.8	11.5	12.8	13.5	14.9	16.1	17.0	16.8	16.6	15.8	14.7	14.2	14.1	13.7	13.2	5.5	17.0
28	12.9	12.6	12.5	11.4	11.1	11.0	11.2	12.7	14.4	13.5	14.7	15.6	16.7	18.3	18.6	19.1	19.1	18.8	17.5	16.7	16.7	16.3	16.0	15.4	11.0	19.1
29	14.3	14.2	14.1	13.2	13.1	13.0	13.1	14.3	15.9	15.8	16.2	17.3	18.5	19.5	20.0	20.7	20.6	20.2	18.5	17.0	17.0	16.6	16.2	16.2	13.0	20.7
30	15.5	15.5	15.6	15.3	15.0	14.8	14.8	16.0	17.7	17.8	17.0	17.4	17.2	18.0	18.5	17.8	17.3	16.5	16.1	16.0	15.9	15.7	15.5	15.8	14.8	18.5
AV	9.9	9.6	9.2	9.0	8.9	8.6	8.4	8.9	9.8	10.6	11.4	12.3	13.1	13.9	12.7	13.4	14.3	13.8	12.9	11.9	11.4	11.0	10.6	10.4	[illegible]	[illegible]
MI	-2.1	-2.2	-2.2	-2.2	-2.4	-2.7	-2.9	-2.3	-1.8	-2.1	-2.2	-2.3	-2.2	-2.0	-33.5	-14.6	-1.3	-1.4	-1.5	-1.6	-1.8	-1.8	-1.9	-2.0	-33.5	[illegible]
MX	18.8	18.5	18.3	18.2	17.9	17.4	17.2	17.3	17.7	19.2	20.4	22.1	24.5	25.7	26.3	26.3	25.9	24.1	22.0	20.7	19.7	19.3	19.2	19.1	[illegible]	26.3

UNFLAGGED MONTHLY AVG 11.1 MONTHLY MIN -33.5 DAY 26 HR 14 [8]: RANGE CHECK MIN 2.0 MAX 25.0 [8]: MAX RATE OF CHANGE 10.0
MAX 26.3 DAY 14 HR 15 [*]: MULTIPLE FLAGS.

OUOOO3 [Program: EDMS_MONTHSUM Version: LC.12-MAY-93]

FIGURE 1.5. An example of a time-series plot generated by AeroVironment.



these invalidations were limited to obvious failures of the meteorological sensor or data acquisition system, acts of nature (e.g., freezing or wind instruments following precipitation), and maintenance. All remaining flagged values were investigated by the meteorological analysis team to determine the validity of the data. In this phase of the task, we used daily weather maps (available from 1987 to the present) to help determine the validity of apparent anomalous data. Flagged data, which the meteorological analysis team found unacceptable, were marked for invalidation from the data base. Where Site audit and service records showed systematic problems with the data, the meteorological analysis team determined if the data could be corrected (i.e., adjusted) with reasonable confidence. Data which could not be salvaged were marked for invalidation.

Once these tasks were completed, AV met with the contracting officer to discuss the findings of the meteorological analysis team and the overall status of the data base. In this meeting we provided the contracting officer with information concerning additional characteristics and peculiarities identified in the data during the validation process. We showed all periods of data that had been marked for invalidation and adjustments, along with supporting documentation. An agreement was reached concerning the final form of the data base.

In accordance with this agreement the data base was edited and corrected. All corrections and edits were reviewed by an unbiased person not involved with the validation process. When all data edits and corrections had been reviewed and confirmed, new monthly data files of validated data were created in the archive format specified by the contracting officer. The newly created data base was then supplied to the contracting officer with the old and new formats on 150 MB Bernoulli disks (for DOS).

Section 2

DATA PRODUCTS

The data products included in this section were produced in accordance with the Subtask list specified in the statement of work for this project. Section IV (Scope), Task A.7, Subtasks a-aaa specified the products that were produced using the 1984-1993 data set. Task B.2 directed us to incorporate the 1953-1977 data (which is made up of the 1953-1976 annual summaries and the 1964-1977 monthly summaries) into Task A. Additionally, Task C.2 directed us to incorporate the Clear-Vu rain gauge data collected on Building 771 with the precipitation data in Tasks A.7 and B.2.

As noted in Section 1.3.1, the data in the three data sets differ in the parameters collected and the time scales of the data. Because of these variations, the analyses were made based upon either the entire merged data set (1953-1993, excluding 1977-1983), the 1964-1977 and 1894-1993 data sets or the 1984-1993 data set only.

2.1 MONTHLY MEAN TEMPERATURES AND PRECIPITATION

Of the three bar charts specified (temperature, precipitation and snowfall), only charts for temperature (Figure 2.1) and precipitation (Figure 2.2) were possible. Snowfall data for the Site were not available. Comparisons with Denver data were also not possible because of the difficulty in obtaining that data set.

2.2 NORMALS AND EXTREMES

Data used in the make up of Table 2.1 are as follows

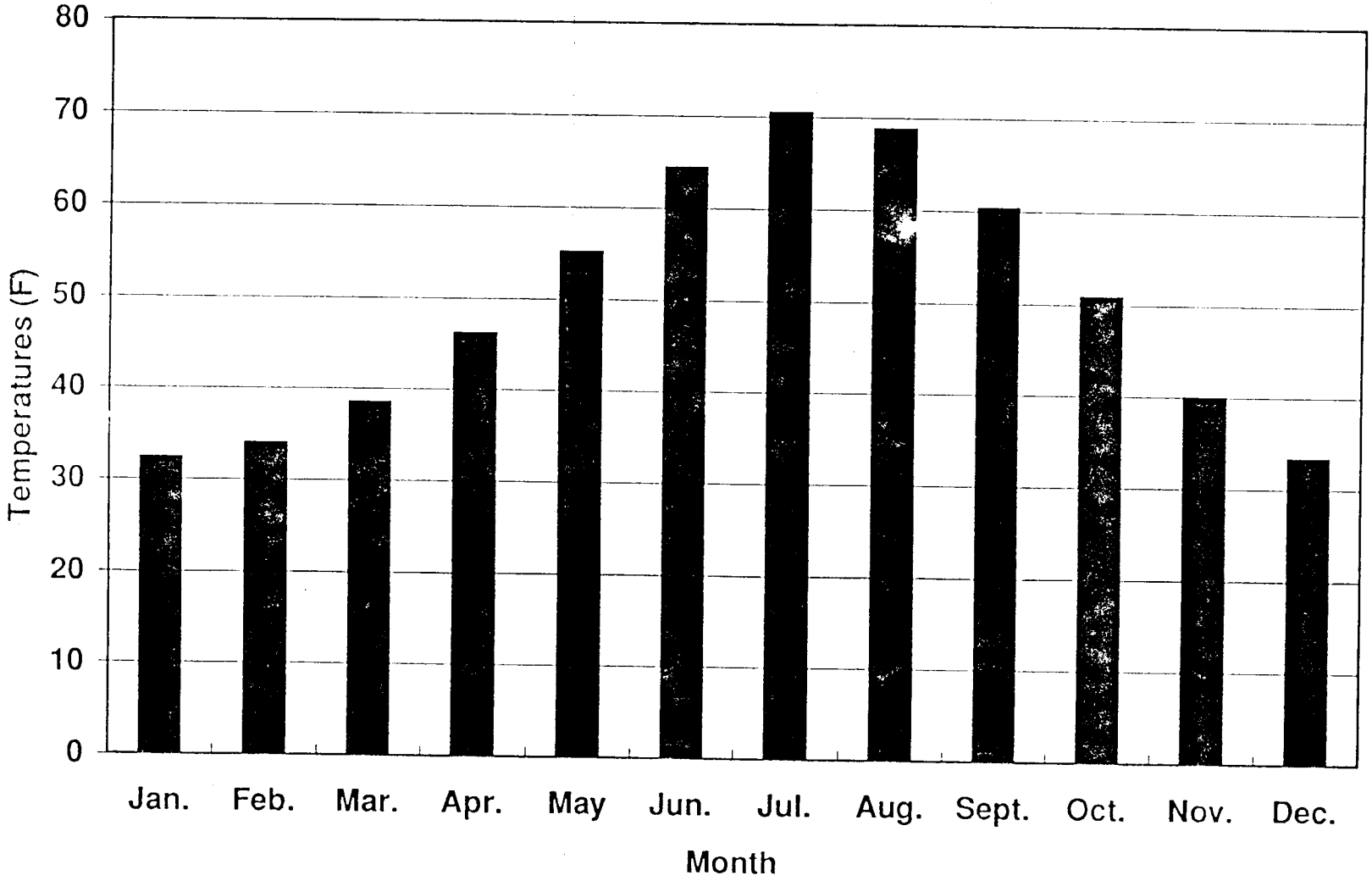
- Data dealing with daily temperatures were based on the 1964-1977 and 1984-1993 data sets only. Daily temperature data were not available before 1964.

- Data dealing with daily relative humidity were based on the 1984-1993 data set only. The tables required average maximum, minimum and mean daily relative humidity which could only be calculated from hourly data. Hourly relative humidity data were not available before 1984.

- Data dealing with dew-point temperature were based on the 1964-1977 and 1984-1993 data sets only. Dew-point temperature data were not available before 1964.

- Data dealing with insolation were based on the 1964-1977 and 1984-1993 data sets. Insolation measurements were not performed before 1964.

FIGURE 2.1. Average Monthly Temperatures at SITE (1953-1977,1984-1993).



SITE1.XLS-24.1.95 Chart-a1

FIGURE 2.2. Average Monthly Precipitation at SITE (1953-1977,1987-1993).

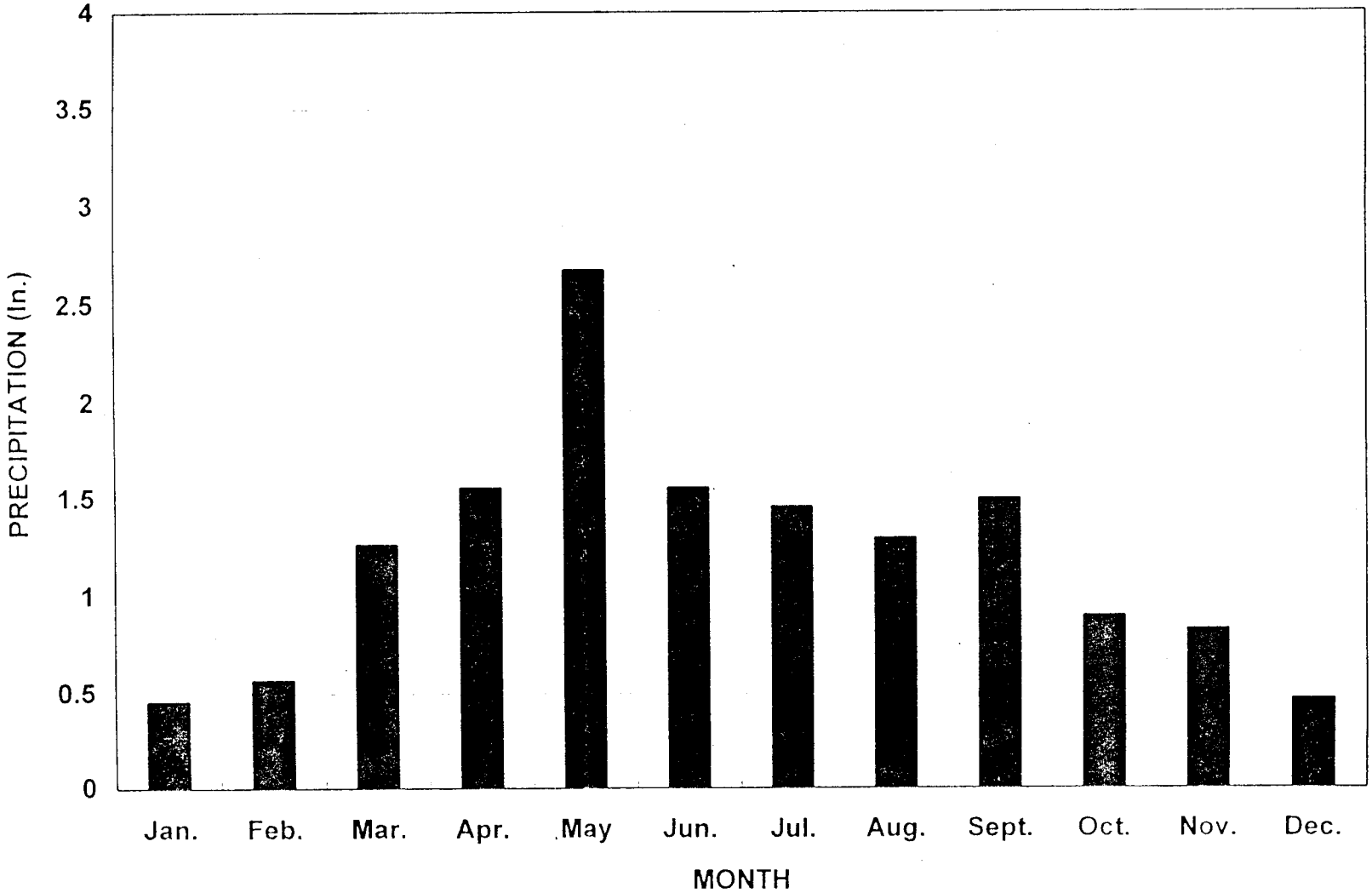


TABLE 2.1. Normals, Means and Extremes at SITE (1964-1977,1984-1993).

	Temperature (F)										
	Normals				Extremes						
	Maximum	Minimum	Average	High Average	Year	Low Average	Year	Maximum	Date	Minimum	Date
Jan.	41.0	23.5	32.3	40.2	1986	19.4	1984	69.0	1/16/74	-12.0	1/4/72
Feb.	42.9	25.3	34.0	40.4	1991	22.9	1964	71.0	2/28/72	-8.7	2/1/85
Mar.	47.4	29.3	38.3	46.5	1972	28.0	1965	82.0	3/26/71	-5.0	3/25/65
Apr.	55.3	36.7	46.1	52.0	1992	38.4	1973	80.7	4/30/92	5.0	4/9/73
May	64.5	45.8	55.1	61.3	1974	48.0	1969	89.0	5/28/74	26.0	5/1/70
Jun.	74.5	54.5	64.4	71.8	1971	58.9	1969	99.0	6/23/71	34.8	6/10/75
Jul.	80.7	60.2	70.5	75.9	1966	66.1	1992	102.0	7/12/71	37.6	7/17/75
Aug.	78.8	59.0	68.9	72.6	1970	65.2	1992	97.0	8/8/89	45.6	8/30/93
Sept.	69.7	50.8	60.3	65.5	1969	53.2	1965	91.0	9/10/74	24.0	9/19/71
Oct.	60.1	41.2	50.8	57.1	1965	38.8	1969	82.1	10/16/91	4.0	10/14/69
Nov.	48.2	31.4	39.9	51.0	1965	33.4	1972	72.0	11/25/70	-3.3	11/24/93
Dec.	42.1	24.5	33.4	39.7	1976	25.8	1990	72.0	12/4/65	-23.6	12/21/90
Annual	58.8	40.2	49.5	52.5	1988	31.3	1985	102.0	7/12/71	-23.6	12/21/90

	Relative Humidity (%)			Mean Dew Point (F)	Mean Wind			Percentage of Possible Insolation	Average Station Pressure (in.)
	Daily Maximum	Daily Minimum	Daily Average		Speed (mph)	Direction Day	Direction Night		
Jan.	89	13	43	13.7	5.7	WNW	WNW	83.0	24.0
Feb.	92	14	48	15.8	5.0	NNW	WNW	80.6	24.0
Mar.	85	17	46	20.4	4.9	NW	W	72.4	24.0
Apr.	89	14	47	27.1	4.8	NNW	W	69.2	24.0
May	90	15	45	34.6	4.5	NNE	W	67.8	24.1
Jun.	84	13	43	43.2	4.1	NNE	W	68.1	24.1
Jul.	86	14	42	48.2	4.0	NNE	W	67.8	24.2
Aug.	82	15	42	46.1	3.8	NNE	W	66.0	24.2
Sept.	75	16	40	38.9	3.8	N	W	73.7	24.2
Oct.	85	15	41	28.8	3.9	SSW	W	75.7	24.2
Nov.	87	14	40	20.4	4.8	WNW	W	82.2	24.1
Dec.	89	13	44	14.2	4.9	WNW	WNW	84.0	24.0
Annual	86	15	44	29.3	4.5	WNW	WNW	74.2	24.1

TABLE 2.1 (Continued).

	Precipitation(in.) Water Equivalent						Mean number of days of occurrences: Temperature (F) Maximum		Minimum		Water Equivalent(in.)		
	Mean	Median	Max	Year	Max Daily	Date	90 and Above	32 and Below	32 and Below	0 and Below	0.01 or More	0.1 or More	0.5 or More
Jan.	0.42	0.30	1.73	1959	0.50	1/12/72	0	7	21	3	4	2	1
Feb.	0.54	0.50	1.81	1959	0.70	2/20/71	0	6	20	2	4	2	1
Mar.	1.19	0.85	4.20	1970	1.06	3/30/70	0	5	17	2	7	4	2
Apr.	1.51	1.20	4.73	1973	2.30	4/13/67	0	2	9	-	7	4	2
May	2.65	1.96	9.70	1969	3.40	5/6/69	0	0	2	-	8	5	2
Jun.	1.56	1.17	4.79	1969	2.94	6/27/87	4	-	0	-	8	4	2
Jul.	1.46	1.26	5.10	1965	1.46	7/20/86	5	-	0	-	9	4	2
Aug.	1.29	1.00	3.69	1967	2.10	8/30/67	3	-	0	-	8	4	1
Sept.	1.43	1.12	4.53	1976	1.81	9/26/76	1	-	4	-	7	4	2
Oct.	1.02	0.53	4.83	1969	1.83	10/4/84	0	2	6	-	5	3	2
Nov.	0.79	0.68	2.00	1972	0.75	11/1/72	0	4	16	2	5	3	1
Dec.	0.44	0.31	1.50	1958	0.50	12/23/73	0	7	22	3	4	2	1
Annual	14.30	10.88	25.72	1969	3.40	5/6/69	13	32	118	12	76	41	18

- Data requiring hourly wind direction and speed data were based on the 1984-1993 data set only. Hourly wind direction and speed data were not available before 1984.

- Data dealing with barometric pressure were based on the 1964-1977 and 1984-1993 data sets only. Barometric pressure data were not available before 1964.

- Data dealing with daily precipitation were based on the 1964-1977 and 1987-1993 data sets only. Daily precipitation data were not available before 1964. Precipitation data for years 1984-1986 were excluded due to the data being incomplete.

2.3 TEMPERATURE AND MOISTURE

2.3.1 Monthly Mean Temperatures

The specified bar chart (Figure 2.3) and table (Table 2.2) do not include Denver data for comparison due to the nonavailability of Denver data.

Differences exist between the data in this chart and the data in the table presented in Section 2.2. This chart encompasses all data collected between 1953 and 1993 while the data in Table 2.1 exclude the data collected before 1964. The differences are tied to the greater range of temperatures characteristic to the Building 123 location as compared to the West Buffer Zone. Because the Table 2.1 data are made up of a greater proportion of West Buffer Zone data than the Figure 2.3 data, the temperature ranges will be less.

FIGURE 2.3. Average Maximum and Minimum Temperature at SITE (1953 - 1977, 1984 - 1993).

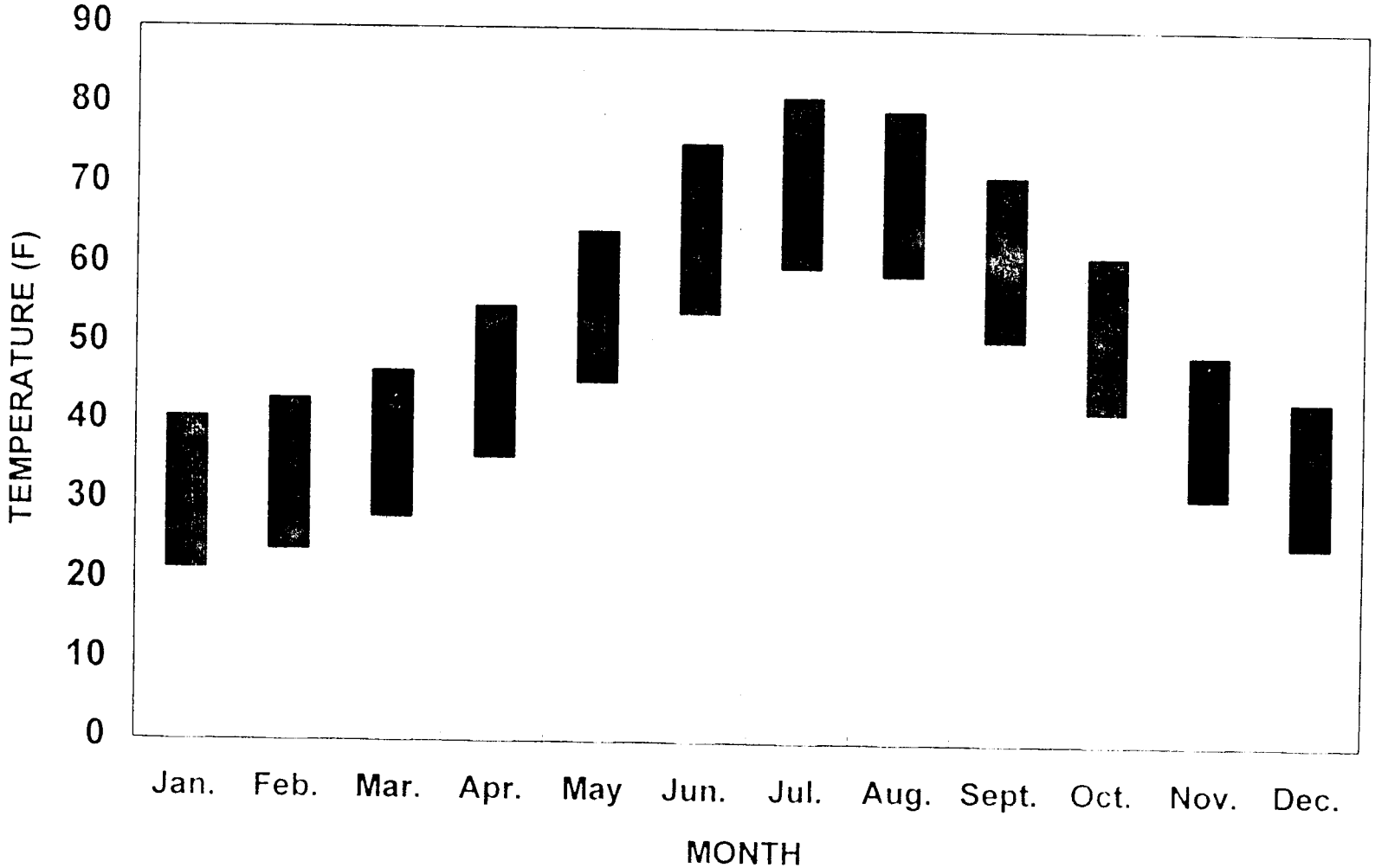


TABLE 2.2. Monthly Mean Temperatures (Degree F) at SITE (1953-1977, 1984-1993).

	Maximum	Minimum	Daily Range	Average
JANUARY	40.7	21.5	19.2	31.1
FEBUARY	43.1	23.9	19.2	33.5
MARCH	46.8	28.1	18.7	37.4
APRIL	55.0	35.5	19.5	45.3
MAY	64.5	45.2	19.4	54.9
JUNE	75.4	54.1	21.4	64.7
JULY	81.3	59.9	21.4	70.6
AUGUST	79.7	59.0	20.7	69.3
SEPTEMBER	71.5	50.7	20.8	61.1
OCTOBER	61.6	41.6	20.0	51.6
NOVEMBER	49.2	30.9	18.4	40.1
DECEMBER	43.4	24.9	18.5	34.1
ANNUAL	59.4	39.6	19.8	49.5

2.3.2 Hourly Temperatures and Humidity

The specified tables (Tables 2.3 through 2.14) and figures (Figure 2.4 through 2.7) do not include Denver data for comparison due to the nonavailability of Denver data. The tables and figures were based on the 1984-1993 data set only. Hourly data were not available before 1984.

Average temperatures and humidity values do not appear to change much from hour to hour each month. A check of the raw data revealed a scatter of values that encompassed the normal range of temperatures for all periods. The averages of these ranges give the false impression that the measurements are incorrect.

TABLE 2.3. January Hourly Temperature, Wet-bulb Temperature, and Relative Humidity, Dew-point Temperature, Mixing Ratio, and Absolute Humidity (1984-1993).

	Temperatures (F)			Wet-Bulb	Relative	Dew-Point	Mixing	Absolute
Hour	Avg.	Upper 10%	Lower 10%	Temp. (F)	Humidity (%)	Temp. (F)	Ratio (g/kg)	Humidity (g/m3)
0	30.7	45.0	13.1	23.1	43.8	8.9	1.9	1.9
1	30.3	45.0	12.1	23.0	43.6	8.5	1.8	1.9
2	30.2	44.7	11.8	22.5	43.6	8.3	1.8	1.9
3	30.2	44.4	11.7	22.9	43.3	8.4	1.8	1.9
4	30.2	44.6	11.2	22.7	43.3	8.1	1.8	1.9
5	30.1	44.5	11.2	22.5	42.9	7.9	1.8	1.9
6	30.0	44.9	11.7	22.6	43.0	7.8	1.8	1.8
7	30.1	44.8	12.1	22.6	43.2	7.9	1.8	1.9
8	30.4	45.2	12.5	22.9	43.1	8.2	1.8	1.9
9	31.2	45.9	13.0	23.4	43.0	9.1	1.9	1.9
10	32.6	47.0	14.2	24.5	43.5	10.4	2.0	2.0
11	33.6	47.9	15.3	25.5	43.5	11.2	2.1	2.1
12	34.7	48.9	16.0	26.3	42.4	11.7	2.1	2.2
13	35.3	50.5	15.7	26.5	42.0	12.1	2.1	2.2
14	35.7	50.3	16.0	26.8	41.6	12.2	2.2	2.2
15	35.6	49.9	16.8	27.1	41.8	12.2	2.2	2.2
16	34.9	48.6	15.7	26.0	42.2	11.9	2.1	2.2
17	33.3	47.2	14.4	25.2	43.7	11.3	2.1	2.2
18	32.3	46.7	13.3	24.6	44.2	10.7	2.0	2.1
19	31.8	45.7	12.8	24.2	44.3	10.3	2.0	2.1
20	31.4	45.1	12.1	23.8	44.2	9.9	2.0	2.0
21	31.1	45.2	12.0	23.6	44.2	9.6	1.9	2.0
22	30.9	45.2	12.2	23.2	44.5	9.4	1.9	2.0
23	30.7	44.9	12.1	23.3	44.2	9.1	1.9	2.0
Avg.	32.0			24.1	43.3	9.8	2.0	2.0

ABLE 2.4. February Hourly Temperature, Wet-bulb Temperature, and Relative Humidity, Dew-point Temperature, lixing Ratio, and Absolute Humidity (1984-1993).

Hour	Temperatures (F) Avg.	Upper 10%	Lower 10%	Wet-Bulb Temp. (F)	Relative Humidity (%)	Dew-Point Temp. (F)	Mixing Ratio (g/kg)	Absolute Humidity (g/m3)
0	32.3	45.2	15.9	25.5	49.2	13.0	2.3	2.3
1	31.9	44.6	16.2	25.2	49.4	12.7	2.2	2.3
2	31.6	44.4	16.4	24.9	49.8	12.6	2.2	2.3
3	31.5	44.5	16.6	24.7	49.4	12.3	2.2	2.2
4	31.2	44.8	15.9	24.5	49.4	12.1	2.2	2.2
5	31.2	45.2	15.8	24.2	49.2	12.0	2.1	2.2
6	30.9	44.4	15.3	24.2	49.1	11.7	2.1	2.2
7	30.9	44.1	15.6	24.1	48.7	11.6	2.1	2.2
8	31.5	44.8	14.8	24.7	49.1	12.3	2.2	2.2
9	32.9	46.7	15.2	25.6	48.8	13.4	2.3	2.3
10	34.7	48.0	17.3	27.0	47.6	14.4	2.4	2.4
11	36.4	49.7	19.0	28.3	45.6	15.0	2.4	2.5
12	37.9	51.0	19.9	29.3	43.9	15.5	2.5	2.5
13	38.6	51.8	20.0	29.6	43.2	15.6	2.5	2.5
14	39.3	52.9	21.7	29.8	42.5	15.8	2.5	2.5
15	39.1	52.9	19.9	29.8	42.6	15.7	2.5	2.5
16	38.5	52.3	19.1	29.4	43.5	15.6	2.5	2.5
17	37.0	50.6	17.6	28.6	45.8	15.5	2.5	2.5
18	35.2	48.5	16.7	27.5	47.7	14.9	2.4	2.5
19	34.2	47.7	15.9	26.9	48.8	14.5	2.4	2.5
20	33.8	47.0	15.3	26.5	48.6	14.1	2.4	2.4
21	33.4	46.2	14.9	26.2	48.9	13.9	2.3	2.4
22	33.1	45.9	16.2	26.1	49.2	13.8	2.3	2.4
23	32.8	45.5	15.9	25.8	49.3	13.5	2.3	2.4
Avg.	34.2			26.6	47.5	13.8	2.3	2.4

TABLE 2.5. March Hourly Temperature, Wet-bulb Temperature, and Relative Humidity, Dew-point Temperature, Mixing Ratio, and Absolute Humidity (1984-1993).

Hour	Temperatures (F) Avg.	Upper 10%	Lower 10%	Wet-Bulb Temp. (F)	Relative Humidity (%)	Dew-Point Temp. (F)	Mixing Ratio (g/kg)	Absolute Humidity (g/m3)
0	36.8	48.6	22.6	29.5	50.2	18.1	2.8	2.8
1	36.4	49.0	21.9	29.3	50.4	17.7	2.7	2.8
2	36.0	48.3	21.6	28.9	50.7	17.4	2.7	2.8
3	35.5	47.9	21.4	28.6	50.9	17.1	2.7	2.7
4	35.2	47.2	21.3	28.3	51.1	16.8	2.6	2.7
5	34.9	46.6	20.9	28.1	51.2	16.7	2.6	2.7
6	34.7	46.6	20.9	27.9	50.7	16.4	2.6	2.6
7	35.0	47.0	21.1	28.2	50.9	16.7	2.6	2.7
8	36.4	48.7	22.0	29.2	50.1	17.6	2.7	2.7
9	38.2	50.3	22.6	30.5	48.7	18.5	2.8	2.8
10	39.9	52.4	24.0	31.4	46.6	18.9	2.8	2.9
11	41.6	54.7	25.1	32.6	45.0	19.5	2.9	2.9
12	43.0	56.2	26.8	33.4	43.5	19.8	2.9	3.0
13	44.2	57.7	27.7	34.2	42.8	20.1	3.0	3.0
14	45.0	58.4	28.9	34.4	41.4	19.9	3.0	3.0
15	45.3	58.9	28.9	34.5	40.9	19.9	3.0	3.0
16	44.9	58.3	27.9	34.3	41.4	19.8	3.0	3.0
17	44.2	57.3	27.3	34.0	42.3	19.9	3.0	3.0
18	42.6	55.6	26.4	33.1	44.2	19.6	2.9	3.0
19	41.0	53.4	26.0	32.1	45.5	19.1	2.9	2.9
20	39.8	51.9	25.1	31.5	47.3	19.0	2.9	2.9
21	39.0	50.8	24.3	31.0	48.2	18.8	2.9	2.9
22	38.2	50.2	23.5	30.5	49.3	18.8	2.9	2.9
23	37.5	49.0	23.1	30.1	49.8	18.5	2.8	2.9
Avg.	39.4			31.1	47.2	18.5	2.8	2.9

ABLE 2.6. **April Hourly Temperature, Wet-bulb Temperature, and Relative Humidity, Dew-point Temperature, ixing Ratio, and Absolute Humidity (1984-1993).**

Hour	Temperatures (F) Avg.	Upper 10%	Lower 10%	Wet-Bulb Temp. (F)	Relative Humidity (%)	Dew-Point Temp. (F)	Mixing Ratio (g/kg)	Absolute Humidity (g/m3)
0	43.0	53.9	29.8	34.9	50.7	24.1	3.5	3.6
1	42.4	53.4	29.6	34.5	51.4	23.7	3.5	3.5
2	41.8	53.1	29.3	34.0	51.8	23.4	3.5	3.5
3	41.4	52.6	29.0	33.6	52.0	23.0	3.4	3.4
4	41.0	52.4	29.0	33.4	51.8	22.7	3.4	3.4
5	40.6	52.2	28.9	33.1	51.6	22.4	3.3	3.4
6	40.6	51.7	28.7	33.2	51.0	22.2	3.3	3.3
7	41.5	53.3	29.0	33.9	51.1	23.0	3.4	3.4
8	43.5	55.6	30.3	35.0	49.6	24.0	3.6	3.6
9	45.3	58.0	31.6	36.2	47.9	24.7	3.7	3.7
10	47.1	60.2	32.4	37.2	46.5	25.2	3.7	3.7
11	48.5	61.8	32.7	37.9	44.6	25.2	3.7	3.7
12	49.9	63.3	33.1	38.7	42.4	25.1	3.7	3.7
13	50.8	64.0	33.6	39.0	41.1	25.0	3.7	3.7
14	51.5	64.3	34.2	39.3	40.7	25.2	3.7	3.7
15	51.8	65.3	34.8	39.6	40.6	25.4	3.8	3.7
16	51.7	64.9	35.4	39.5	40.6	25.4	3.8	3.7
17	51.2	64.4	34.9	39.3	41.4	25.6	3.8	3.8
18	50.1	63.2	34.1	39.0	43.1	25.8	3.8	3.8
19	48.3	61.2	33.2	38.2	45.4	25.8	3.8	3.8
20	46.8	59.4	32.8	37.5	47.4	25.6	3.8	3.8
21	45.8	57.7	32.3	36.8	48.4	25.3	3.7	3.8
22	44.9	56.5	31.6	36.4	49.0	24.8	3.7	3.7
23	43.9	55.3	30.6	35.5	49.9	24.5	3.6	3.6
Avg.	46.0			36.5	47.1	24.5	3.6	3.6

TABLE 2.7. May Hourly Temperature, Wet-bulb Temperature, and Relative Humidity, Dew-point Temperature, Mixing Ratio, and Absolute Humidity (1984-1993).

	Temperatures (F)			Wet-Bulb	Relative	Dew-Point	Mixing	Absolute
Hour	Avg.	Upper 10%	Lower 10%	Temp. (F)	Humidity (%)	Temp. (F)	Ratio (g/kg)	Humidity (g/m3)
0	51.8	61.0	39.9	41.5	46.7	30.6	4.6	4.6
1	51.3	60.8	39.2	41.2	47.6	30.3	4.6	4.5
2	50.5	59.9	38.1	40.8	48.6	30.2	4.5	4.5
3	50.0	59.7	37.4	40.5	49.6	30.1	4.5	4.5
4	49.1	58.3	37.4	40.1	50.6	29.8	4.5	4.5
5	48.6	57.8	37.4	39.8	51.2	29.7	4.4	4.4
6	48.9	58.6	37.5	39.9	51.9	30.4	4.6	4.6
7	50.6	60.5	38.4	41.5	51.3	31.8	4.8	4.8
8	52.6	63.6	39.4	42.7	49.3	32.6	5.0	4.9
9	54.5	66.5	40.2	43.6	46.9	33.0	5.1	5.0
10	56.6	69.3	41.8	44.7	43.5	33.0	5.1	5.0
11	58.4	70.6	43.0	45.5	41.2	33.1	5.1	5.0
12	59.6	72.4	43.9	45.9	39.5	32.9	5.1	5.0
13	60.6	73.1	44.3	46.3	38.1	32.6	5.0	4.9
14	61.2	73.9	44.9	46.7	37.7	32.8	5.0	4.9
15	61.7	73.9	46.1	46.8	36.7	32.6	5.0	4.9
16	61.7	74.1	46.4	46.8	36.8	32.7	5.0	4.9
17	61.2	73.4	46.6	46.6	37.8	33.0	5.1	5.0
18	59.8	71.4	45.9	46.1	39.8	33.1	5.1	5.0
19	58.0	69.3	44.3	45.5	42.0	33.1	5.1	5.0
20	56.2	66.5	44.0	44.5	43.9	32.7	5.0	5.0
21	54.8	64.8	42.7	43.5	45.0	32.3	4.9	4.9
22	53.7	63.6	41.7	43.0	46.2	32.0	4.9	4.8
23	52.8	62.7	40.9	42.4	46.5	31.5	4.7	4.7
Avg.	55.2			43.6	44.5	31.9	4.9	4.8

ABLE 2.8. **June Hourly Temperature, Wet-bulb Temperature, and Relative Humidity, Dew-point Temperature,** lixing Ratio, and Absolute Humidity (1984-1993).

Hour	Temperatures (F) Avg.	Upper 10%	Lower 10%	Wet-Bulb Temp. (F)	Relative Humidity (%)	Dew-Point Temp. (F)	Mixing Ratio (g/kg)	Absolute Humidity (g/m3)
0	60.0	68.2	50.0	48.2	46.8	38.1	6.1	6.0
1	59.4	67.6	49.4	47.7	47.2	37.7	6.1	6.0
2	58.7	66.3	48.9	47.3	47.7	37.4	6.0	5.9
3	58.0	66.3	48.5	46.8	48.2	37.0	5.9	5.8
4	57.4	65.3	47.9	46.4	48.5	36.6	5.8	5.7
5	57.0	64.5	47.9	46.2	48.9	36.5	5.8	5.7
6	57.8	65.0	49.1	46.9	49.0	37.3	6.0	5.9
7	59.5	68.2	50.1	48.3	48.8	38.8	6.3	6.2
8	61.8	72.0	51.2	49.6	47.3	40.0	6.6	6.5
9	63.8	74.5	52.6	50.7	45.0	40.4	6.8	6.6
10	65.7	76.0	54.1	51.4	42.2	40.5	6.8	6.6
11	67.4	77.5	55.2	51.9	40.0	40.4	6.8	6.6
12	68.8	78.8	56.3	52.5	38.0	40.2	6.7	6.5
13	69.9	80.0	58.3	52.7	36.4	39.9	6.7	6.4
14	70.5	80.2	58.9	53.1	35.6	39.8	6.6	6.4
15	70.5	80.1	58.7	53.0	35.6	39.8	6.6	6.4
16	70.2	79.6	57.4	52.9	36.1	39.8	6.6	6.4
17	69.6	78.0	57.2	52.6	36.8	39.8	6.6	6.4
18	68.7	78.0	55.9	52.3	37.9	39.9	6.6	6.4
19	67.0	75.7	54.5	51.7	40.2	40.1	6.7	6.5
20	64.9	73.5	53.1	50.8	42.5	39.8	6.6	6.4
21	63.4	72.1	52.3	50.1	43.8	39.4	6.5	6.3
22	62.3	70.1	51.9	49.3	44.6	38.9	6.3	6.2
23	61.2	69.1	50.9	48.8	45.7	38.5	6.3	6.1
Avg.	63.9			50.1	43.0	39.0	6.4	6.3

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TABLE 2.9. July Hourly Temperature, Wet-bulb Temperature, and Relative Humidity, Dew-point Temperature, Mixing Ratio, and Absolute Humidity (1984-1993).

Hour	Temperatures (F) Avg.	Upper 10%	Lower 10%	Wet-Bulb Temp. (F)	Relative Humidity (%)	Dew-Point Temp. (F)	Mixing Ratio (g/kg)	Absolute Humidity (g/m3)
0	65.3	72.3	57.1	52.0	45.3	42.0	7.1	7.0
1	64.6	71.9	56.7	51.4	45.8	41.5	7.0	6.9
2	63.9	71.5	56.1	51.1	46.3	41.2	6.9	6.8
3	63.2	71.4	55.1	50.8	47.2	41.0	6.9	6.7
4	62.6	70.3	54.6	50.4	48.0	40.8	6.8	6.7
5	62.2	70.3	54.3	50.1	48.3	40.5	6.8	6.7
6	62.5	70.8	54.2	50.6	48.5	41.1	6.9	6.8
7	64.1	73.0	55.6	51.8	48.6	42.6	7.3	7.2
8	66.4	76.3	57.8	53.1	46.7	43.6	7.6	7.4
9	68.7	78.7	59.7	54.2	44.1	44.2	7.7	7.5
10	71.0	80.5	61.9	55.1	41.2	44.2	7.8	7.5
11	72.7	81.8	63.2	55.7	38.7	44.0	7.7	7.4
12	74.0	82.8	64.5	56.1	36.9	43.9	7.7	7.4
13	75.1	83.5	65.4	56.5	35.6	43.7	7.6	7.3
14	75.7	84.3	65.4	56.6	34.9	43.5	7.6	7.3
15	75.7	84.3	64.9	56.4	34.5	43.4	7.5	7.2
16	75.5	84.0	64.8	56.4	35.0	43.4	7.6	7.3
17	74.8	83.1	63.6	56.2	36.1	43.5	7.6	7.3
18	73.5	81.6	63.1	55.8	37.8	43.6	7.6	7.4
19	71.9	79.6	62.2	55.2	39.9	43.8	7.7	7.4
20	70.0	77.6	61.1	54.4	41.5	43.5	7.5	7.3
21	68.4	75.8	59.5	53.7	42.8	43.1	7.4	7.2
22	67.3	74.6	58.5	53.1	43.7	42.7	7.3	7.1
23	66.2	73.5	57.9	52.5	44.8	42.4	7.2	7.1
Avg.	69.0			53.7	42.2	42.8	7.4	7.2

ABLE 2.10. August Hourly Temperature, Wet-bulb Temperature, and Relative Humidity, Dew-point Temperature, ixing Ratio, and Absolute Humidity (1984-1993).

Hour	Temperatures (F) Avg.	Upper 10%	Lower 10%	Wet-Bulb Temp. (F)	Relative Humidity (%)	Dew-Point Temp. (F)	Mixing Ratio (g/kg)	Absolute Humidity (g/m3)
0	64.6	71.6	56.7	51.3	44.4	41.1	6.8	6.7
1	63.9	71.0	55.8	51.0	45.4	40.8	6.8	6.7
2	63.3	70.9	55.5	50.6	45.3	40.5	6.7	6.6
3	62.8	70.6	54.5	50.2	45.7	40.1	6.6	6.5
4	62.4	70.3	54.1	49.9	45.8	39.8	6.5	6.4
5	61.9	69.2	54.1	49.5	46.0	39.5	6.5	6.4
6	61.8	69.4	53.7	49.5	46.8	39.8	6.5	6.4
7	63.2	70.9	54.6	50.8	47.0	41.2	6.9	6.8
8	65.5	74.0	56.5	52.3	45.5	42.4	7.2	7.1
9	67.7	76.6	58.2	53.2	42.9	42.8	7.3	7.1
10	69.7	78.3	60.1	54.1	40.4	43.1	7.4	7.2
11	71.4	79.9	61.0	54.8	38.5	43.3	7.4	7.2
12	72.6	80.7	62.8	55.2	36.6	43.2	7.4	7.2
13	73.4	81.4	63.3	55.6	35.6	43.1	7.4	7.1
14	73.8	81.9	63.6	55.7	35.1	43.0	7.4	7.1
15	73.8	82.1	62.6	55.6	35.3	43.0	7.4	7.1
16	73.5	81.7	62.5	55.6	35.6	42.9	7.4	7.1
17	72.4	80.7	61.6	55.3	37.4	43.1	7.4	7.2
18	71.2	79.5	60.9	54.9	38.6	43.1	7.4	7.2
19	69.4	77.1	59.3	54.0	40.7	43.0	7.4	7.1
20	67.7	74.7	58.2	53.2	42.1	42.6	7.2	7.0
21	66.7	73.8	57.4	52.7	43.1	42.3	7.1	7.0
22	65.9	73.0	57.1	52.2	43.8	42.0	7.1	6.9
23	65.2	72.5	57.0	51.8	44.0	41.4	6.9	6.8
Avg.	67.7			52.9	41.7	42.0	7.1	6.9

TABLE 2.11. September Hourly Temperature, Wet-bulb Temperature, and Relative Humidity, Dew-point Temperature, Mixing Ratio, and Absolute Humidity (1984-1993).

	Temperatures (F)			Wet-Bulb Temp.	Relative Humidity	Dew-Point Temp.	Mixing Ratio	Absolute Humidity
Hour	Avg.	Upper 10%	Lower 10%	(F)	(%)	(F)	(g/kg)	(g/m3)
0	57.8	66.4	45.2	45.6	43.2	33.9	5.3	5.2
1	57.1	66.0	44.2	45.0	43.7	33.6	5.2	5.2
2	56.6	65.3	43.5	44.9	44.3	33.4	5.2	5.1
3	56.1	65.0	43.0	44.7	44.6	33.2	5.1	5.1
4	55.5	64.1	43.0	44.2	44.8	32.8	5.1	5.0
5	55.1	64.1	42.3	43.7	45.3	32.6	5.0	5.0
6	54.6	63.5	41.7	43.6	45.9	32.4	5.0	5.0
7	55.2	65.0	41.9	44.2	46.3	33.2	5.2	5.1
8	57.2	67.4	43.6	45.6	45.3	34.5	5.4	5.4
9	59.5	70.2	44.6	46.7	42.9	35.1	5.5	5.5
10	61.6	72.7	46.1	47.7	40.6	35.6	5.6	5.5
11	63.3	74.4	47.8	48.8	38.7	36.0	5.7	5.6
12	64.8	75.1	49.0	49.3	36.7	35.8	5.6	5.5
13	66.0	76.1	50.1	49.7	35.2	35.8	5.6	5.5
14	66.9	77.2	51.9	50.2	34.1	35.9	5.7	5.5
15	67.3	77.5	53.1	50.2	33.7	35.6	5.6	5.4
16	67.0	77.2	52.9	50.1	34.3	35.6	5.6	5.5
17	66.3	76.5	52.1	49.8	35.1	35.7	5.7	5.5
18	64.4	74.1	50.7	49.1	37.2	35.7	5.7	5.5
19	62.2	72.0	49.5	48.0	39.2	35.3	5.6	5.5
20	60.9	69.3	48.3	47.3	40.1	34.7	5.5	5.4
21	59.7	68.2	47.4	46.7	41.3	34.4	5.4	5.3
22	58.8	67.5	46.3	46.2	42.1	34.1	5.3	5.3
23	58.2	66.5	45.6	45.9	42.4	33.8	5.3	5.2
Avg.	60.5			47.0	40.7	34.5	5.4	5.3

\BLE 2.12. October Hourly Temperature, Wet-bulb Temperature, and Relative Humidity, Dew-point Temperature, :xing Ratio, and Absolute Humidity (1984-1993).

Hour	Temperatures (F) Avg.	Upper 10%	Lower 10%	Wet-Bulb Temp. (F)	Relative Humidity (%)	Dew-Point Temp. (F)	Mixing Ratio (g/kg)	Absolute Humidity (g/m3)
0	48.3	60.5	30.1	37.5	39.8	23.3	3.4	3.4
1	47.7	60.0	29.7	37.2	40.2	22.9	3.3	3.3
2	47.0	59.4	29.2	36.7	40.8	22.6	3.3	3.3
3	46.6	59.3	28.6	36.2	40.7	22.4	3.2	3.3
4	46.3	58.9	28.4	36.3	40.9	22.2	3.2	3.2
5	46.0	58.5	28.4	36.0	41.5	22.2	3.2	3.3
6	45.6	58.0	28.3	35.8	41.8	22.1	3.2	3.2
7	45.6	57.9	28.7	35.9	42.5	22.4	3.3	3.3
8	46.8	59.8	29.2	36.7	42.7	23.5	3.4	3.4
9	49.0	63.4	29.6	38.1	40.6	24.2	3.5	3.5
10	50.8	65.0	30.8	39.2	39.3	24.9	3.6	3.6
11	52.4	66.6	31.7	40.1	37.7	25.4	3.7	3.7
12	53.8	68.0	32.0	40.9	35.9	25.5	3.7	3.7
13	55.2	69.2	33.6	41.6	34.6	25.8	3.7	3.7
14	55.9	70.1	34.3	42.0	33.9	25.7	3.7	3.7
15	56.3	70.5	35.4	42.1	33.4	25.8	3.7	3.7
16	55.9	69.3	33.9	41.9	33.4	25.5	3.7	3.6
17	54.7	68.1	33.4	41.4	34.5	25.3	3.7	3.6
18	52.8	65.6	32.8	40.5	36.5	25.1	3.6	3.6
19	51.5	63.8	31.6	39.6	37.6	24.6	3.6	3.5
20	50.4	62.3	30.5	38.8	38.4	24.1	3.5	3.5
21	49.5	61.2	30.3	38.5	39.1	23.8	3.4	3.4
22	48.7	60.5	30.2	37.8	39.9	23.6	3.4	3.4
23	48.2	59.9	29.3	37.5	40.2	23.4	3.4	3.4
Avg.	50.2			38.7	38.6	24.0	3.5	3.5

TABLE 2.13. November Hourly Temperature, Wet-bulb Temperature, and Relative Humidity, Dew-point Temperature, Mixing Ratio, and Absolute Humidity (1984-1993).

Hour	Temperatures (F) Avg.	Upper 10%	Lower 10%	Wet-Bulb Temp. (F)	Relative Humidity (%)	Dew-Point Temp. (F)	Mixing Ratio (g/kg)	Absolute Humidity (g/m3)
0	38.3	51.6	22.7	30.2	42.4	15.9	2.5	2.6
1	37.7	50.0	19.8	29.8	42.7	15.6	2.5	2.5
2	37.2	50.2	20.1	29.6	43.0	15.3	2.5	2.5
3	37.2	50.4	20.1	29.2	42.5	15.0	2.4	2.5
4	37.2	50.4	20.2	29.4	41.9	14.7	2.4	2.5
5	37.1	50.6	20.3	29.1	42.0	14.5	2.4	2.4
6	37.0	50.6	20.5	29.2	41.8	14.2	2.4	2.4
7	36.8	50.4	20.3	28.9	42.1	14.2	2.4	2.4
8	37.2	51.2	20.2	29.1	41.8	14.4	2.4	2.4
9	38.6	52.6	20.8	30.3	41.7	15.6	2.5	2.5
10	40.4	54.1	22.1	31.4	39.9	16.4	2.6	2.6
11	41.4	55.9	22.5	32.3	39.3	17.1	2.6	2.7
12	42.7	56.9	23.0	33.0	38.4	17.7	2.7	2.7
13	43.5	57.6	23.7	33.7	37.6	17.9	2.7	2.7
14	44.1	58.2	23.4	33.9	37.2	18.1	2.7	2.7
15	43.9	57.9	23.1	33.7	36.7	17.7	2.7	2.7
16	43.2	57.4	22.6	33.3	37.1	17.4	2.7	2.7
17	41.5	55.0	21.3	32.4	38.9	17.1	2.6	2.7
18	40.2	53.2	20.2	31.6	40.4	16.8	2.6	2.6
19	39.5	52.9	19.6	31.1	40.9	16.5	2.6	2.6
20	39.1	52.3	19.8	31.0	41.7	16.4	2.6	2.6
21	38.8	52.1	20.2	30.6	41.5	16.1	2.5	2.6
22	38.6	51.5	20.8	30.6	41.5	16.1	2.5	2.6
23	38.3	51.0	21.7	30.2	41.9	15.9	2.5	2.6
Avg.	39.6			31.0	40.6	16.1	2.5	2.6

ABLE 2.14. December Hourly Temperature, Wet-bulb Temperature, and Relative Humidity, Dew-point Temperature, ixing Ratio, and Absolute Humidity (1984-1993).

Hour	Temperatures (F) Avg.	Upper 10%	Lower 10%	Wet-Bulb Temp. (F)	Relative Humidity (%)	Dew-Point Temp. (F)	Mixing Ratio (g/kg)	Absolute Humidity (g/m3)
0	31.3	46.5	12.9	23.4	44.5	9.3	1.9	2.0
1	30.9	47.3	12.5	23.1	45.1	9.0	1.9	2.0
2	30.6	46.7	11.8	22.8	44.9	8.8	1.9	2.0
3	30.4	46.2	12.1	22.7	45.4	8.7	1.9	2.0
4	30.2	45.8	12.4	22.4	45.8	8.6	1.9	2.0
5	30.5	45.8	12.1	22.7	44.9	8.5	1.9	2.0
6	30.3	46.4	11.2	22.5	44.9	8.2	1.9	2.0
7	30.2	46.3	11.3	22.6	45.0	8.1	1.9	2.0
8	30.4	46.6	11.8	22.5	44.5	8.1	1.9	2.0
9	31.5	47.9	12.4	23.3	44.4	9.0	1.9	2.0
10	33.2	49.7	13.9	24.9	44.3	10.4	1.9	2.0
11	34.5	51.4	14.7	25.9	43.4	11.4	1.9	2.0
12	34.9	52.0	14.8	26.3	43.4	11.7	1.9	2.0
13	35.6	52.9	15.4	26.4	42.6	12.0	1.9	2.0
14	36.1	53.4	15.5	26.7	42.5	12.3	1.9	2.0
15	35.9	53.0	15.5	26.7	42.2	12.0	1.9	2.0
16	35.0	52.1	14.9	26.0	42.6	11.4	1.9	2.0
17	33.6	49.8	14.1	25.0	43.6	10.7	1.9	2.0
18	32.5	48.3	14.2	24.4	44.6	10.3	1.9	2.0
19	32.2	47.7	14.3	23.9	44.4	10.0	1.9	2.0
20	31.8	47.0	14.0	23.7	44.3	9.6	1.9	2.0
21	31.6	47.3	14.0	23.5	44.0	9.3	1.9	2.0
22	31.4	45.9	13.9	23.3	44.2	9.3	1.9	2.0
23	31.5	46.2	12.9	23.6	44.1	9.3	1.9	2.0
Avg.	32.3			24.1	44.1	9.8	1.9	2.0

FIGURE 2.4. **Mean Temperatures, Relative Humidity, Wet-bulb and Dew-point Temperatures for January (1984-1993).**

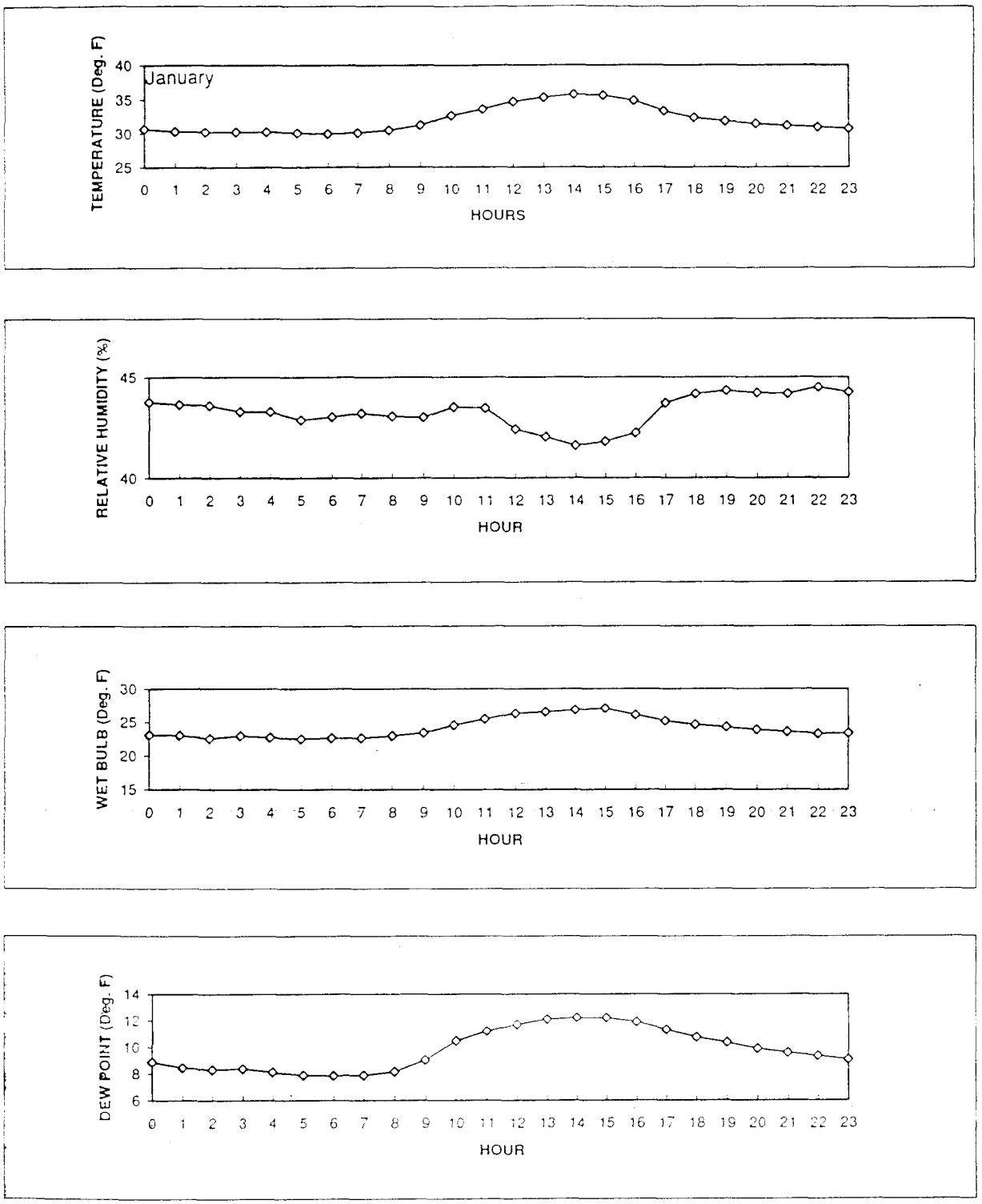


FIGURE 2.5. Mean Temperatures, Relative Humidity, Wet-bulb and Dew-point Temperatures for April (1984-1993).

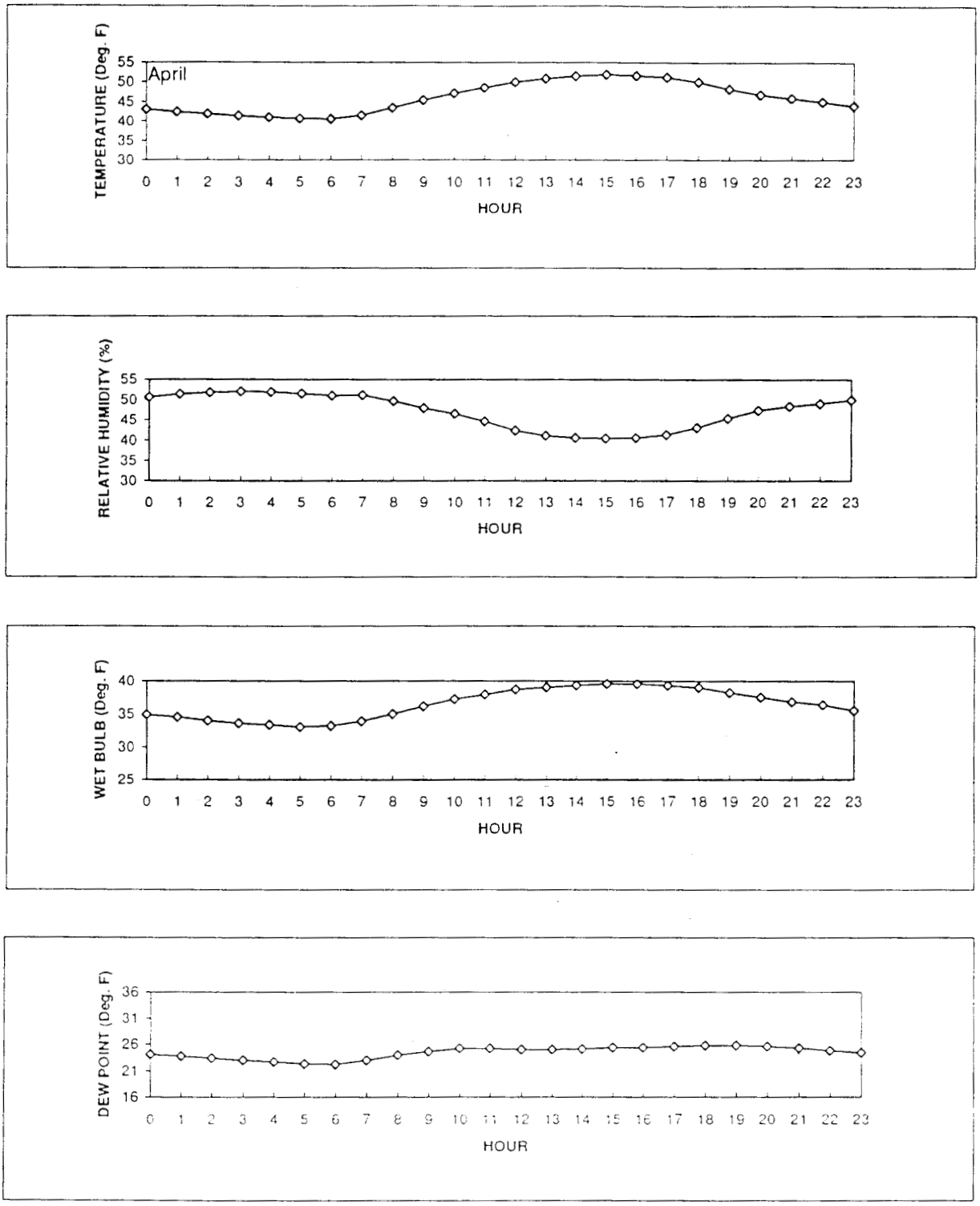


FIGURE 2.6. Mean Temperatures, Relative Humidity, Wet-bulb and Dew-point Temperatures for July (1984-1993).

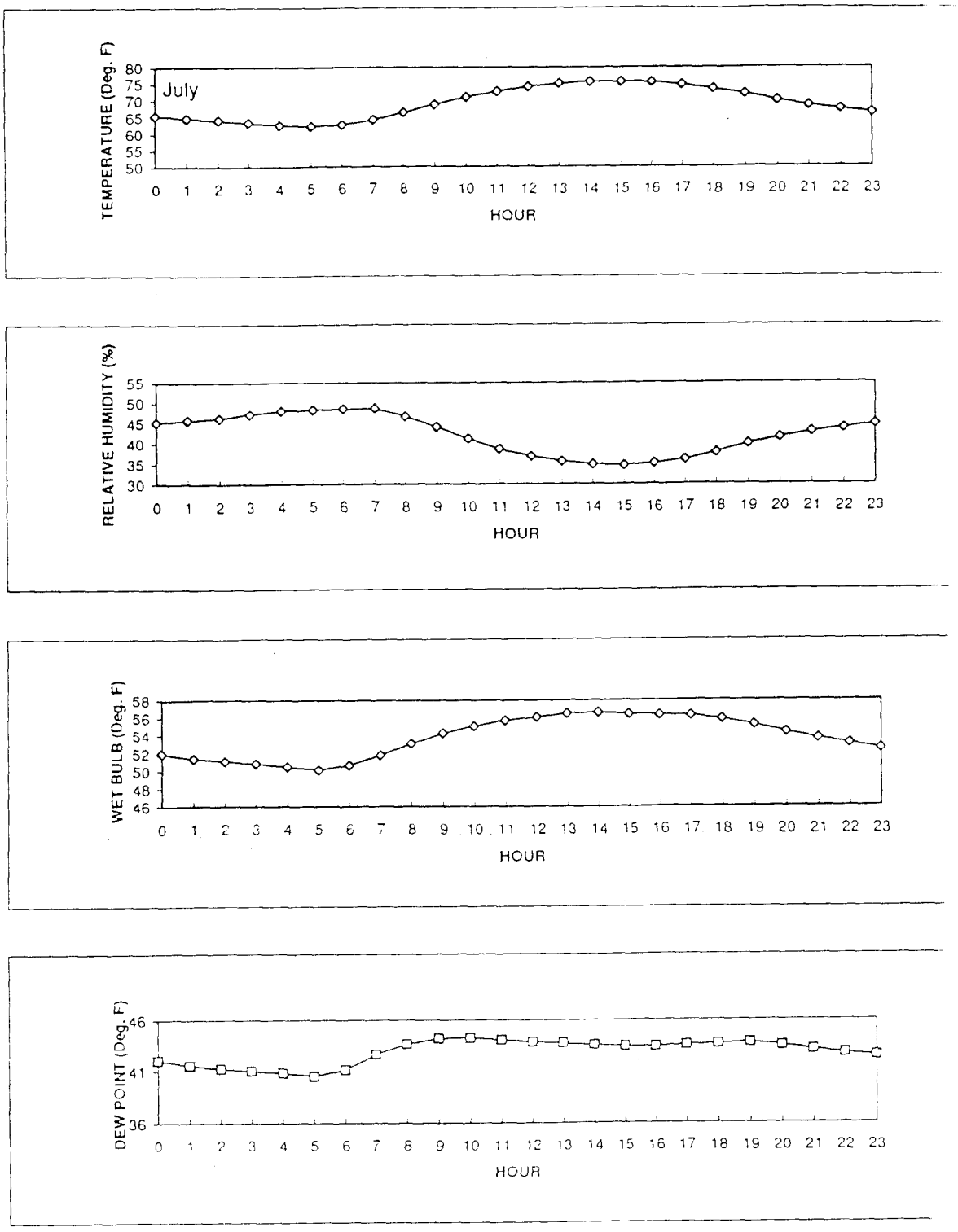


TABLE 2.15. SITE Temperature Probabilities (1964-1977, 1984-1993).

	Low	1%	5%	10%	25%	50%	75%	90%	95%	99%	High	Std Dev
Maximum Temperature (F)												
JAN	2.9	8.0	17.0	23.7	33.0	43.0	50.3	56.0	59.0	64.8	69.0	23
FEB	-2.9	11.0	22.9	27.4	35.0	44.1	52.0	56.4	59.3	64.0	71.0	23
MAR	9.1	17.0	24.3	30.0	38.5	48.6	58.0	64.0	67.0	73.0	82.0	24
APR	20.0	28.7	35.0	39.0	48.0	56.0	64.0	71.0	73.0	77.1	80.7	21
MAY	33.7	38.0	45.0	49.8	56.8	65.5	73.0	78.2	81.4	84.0	89.0	20
JUN	44.0	47.6	57.0	61.8	68.4	75.1	81.1	87.0	90.0	93.0	99.0	19
JUL	50.0	56.0	66.4	70.6	76.1	82.0	86.0	90.0	92.0	95.0	102.0	17
AUG	53.4	55.2	65.8	69.0	74.4	79.6	84.0	87.0	89.0	93.0	97.0	15
SEP	32.3	37.0	49.2	55.0	63.5	72.0	78.0	82.0	84.0	88.0	91.0	21
OCT	13.9	24.0	36.0	42.8	53.0	62.0	70.0	75.1	77.0	80.0	82.1	24
NOV	6.7	20.6	27.7	31.8	39.4	49.6	58.0	63.6	66.8	70.0	72.0	22
DEC	-16.6	11.0	20.0	26.0	34.0	42.7	51.6	58.0	60.7	64.0	72.0	27

	Low	1%	5%	10%	25%	50%	75%	90%	95%	99%	High	Std Dev
Minimum Temperature (F)												
JAN	-12.0	-7.0	-1.0	4.9	16.0	24.9	33.3	40.0	42.0	47.2	53.0	23
FEB	-8.7	-2.0	5.0	10.0	18.2	26.0	34.0	39.6	42.6	46.0	51.0	21
MAR	-5.0	-2.0	7.1	14.0	22.5	29.8	37.5	42.9	46.2	53.0	57.6	22
APR	5.0	8.0	23.6	26.0	31.0	36.0	42.0	48.0	52.0	59.0	64.8	20
MAY	26.0	29.0	32.8	35.5	40.3	46.0	51.4	55.7	59.0	62.7	67.1	14
JUN	34.8	39.0	43.0	46.0	50.0	54.9	59.0	63.0	65.3	72.0	75.5	13
JUL	37.6	46.1	50.9	53.7	57.0	60.0	63.9	67.0	69.0	72.0	77.0	12
AUG	45.6	47.0	50.0	52.0	55.8	59.0	62.6	66.0	67.9	71.0	72.7	10
SEP	24.0	30.0	37.0	40.0	45.5	51.4	57.3	61.0	63.0	66.2	68.8	15
OCT	4.0	11.0	25.0	28.0	34.5	41.8	48.8	54.4	56.9	61.8	64.6	20
NOV	-3.3	4.5	13.0	18.0	24.0	31.3	40.0	47.0	49.3	54.0	58.1	21
DEC	-23.6	-8.6	4.0	8.7	17.0	25.0	33.0	40.0	43.9	50.0	52.7	25

2.3.4 Design Temperatures

Design temperatures represent expected extreme hot and cold conditions based on compiled data. Winter and summer design data are used in specifications for heating, ventilating, and air conditioning equipment. Design temperatures are temperatures that are equaled or exceeded for a specified number of hours in a year. The number of hours is given as a percentage of the 8760 hours contained in a 365-day year. For example, a 0.1% design temperature indicates a temperature that is equaled or exceeded for 8.75 hours during the year. Summer and winter design temperatures were calculated using historical, 15-minute-averaged temperatures. Winter and summer design temperatures represent extreme cold and warm temperatures, respectively, for the entire year, not just for the respective season.

Table 2.16 was based on the 1984-1993 data set only. Hourly data were not available before 1984. As in the example above, this analysis was based on a total of 8760 hours contained in a 365-day year.

See Sections 1.3.2 and 1.4 for a discussion on temperature data quality.

TABLE 2.16. Winter and Summer Design Temperatures at SITE (1984-1993). Column Headings Represent the Percentage of Time* the Temperature is Equaled or Exceed.

	Winter						
	Low	0.1%	0.2%	0.5%	1.0%	2.0%	5.0%
Temperature (Degree F)	-24	-23	-20	-13	-9	-4	2

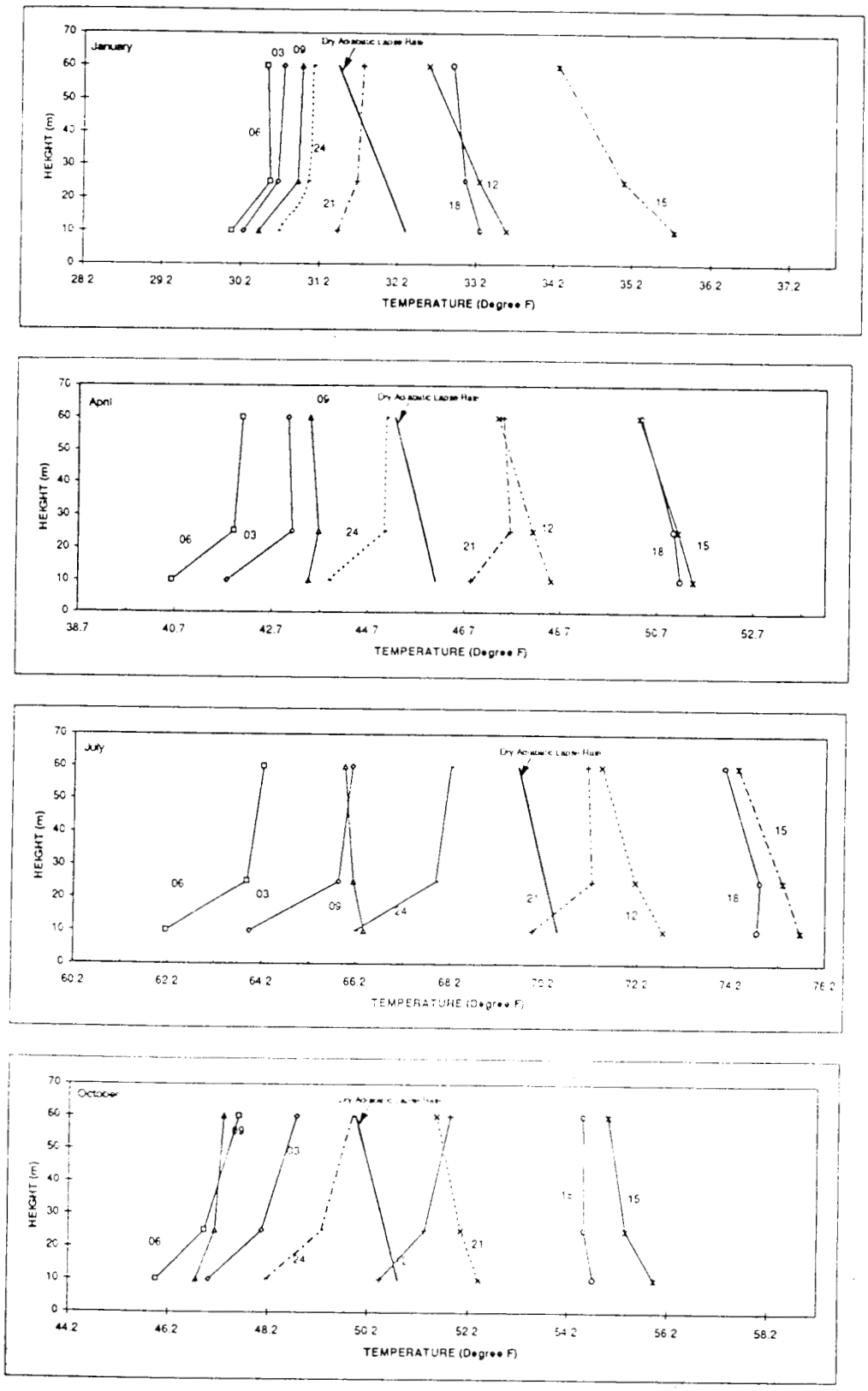
	Summer						
	5.0%	2.0%	1.0%	0.5%	0.2%	0.1%	High
Temperature (Degree F)	87	89	91	92	93	93	94

* Percentage of 8760 hours over 365-day year.

2.3.5 Vertical Temperature Profiles

The temperature profiles presented in Figure 2.8 were constructed from averages of continuous temperature measurements collected at the 10-, 25- and 61-meter levels of the tower at the West Buffer Zone location. The profiles were based on the 1984-1993 data set only. Hourly data were not available before 1984. The ordinant scales differ between the four graphs due to the expected temperature ranges for each season. The profiles are representative of the West Buffer Zone location. See Section 1.4 for a discussion on the quality of these data.

FIGURE 2.8. Vertical Mean Temperature Profiles for January, April, July and October (1984-1993).



2.3.6 Heating Degree Days

A heating-degree day is defined as the number of degrees (Fahrenheit) the daily mean temperature is below a certain temperature; 65°F is a commonly used base. For example, if a certain day has a high temperature of 60°F and a low temperature of 40°F, the daily mean would be 50°F, which would give 15 heating-degree days (from the 65°F base) for this day. Heating-degree days (65° base) are good for estimating fuel requirements for heating and are also used for structural design considerations.

Heating-degree-day data for the base 65°F (Table 2.17) and bases other than 65°F (Table 2.18) were based on the 1984-1993 data set only. Heating-degree-day-data were not available before 1984. The heating-degree day information is representative of the West Buffer Zone location. See Section 1.4 for a discussion of data quality.

TABLE 2.17. SITE Heating-degree Days (65 Degree F base) (1953-1977,1984-1993).

	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	TOTAL
1953	14	17	61	369	669	1023	753	905	732	761	529	73	5906
1954	3	10	110	436	645	892	858	567	971	432	362	71	5357
1955	0	15	163	296	821	880	1078	1084	975	551	278	179	6320
1956	0	0	0	277	835	901	978	1135	791	632	229	0	5778
1957	0	0	150	496	900	744	1178	700	930	750	403	0	6251
1958	0	0	60	372	810	930	1023	868	1116	780	217	0	6176
1959	4	11	206	498	869	997	1101	1028	897	651	407	50	6719
1960	0	0	0	310	600	1110	1138	1120	806	450	248	0	5782
1961	0	0	390	558	930	1147	1085	980	992	1080	434	60	7656
1962	0	0	120	330	690	900	1170	1050	960	540	240	90	6090
1963	0	0	30	248	660	1054	1395	700	868	540	186	0	5681
1964	0	0	90	341	750	186	1178	1218	1054	630	248	180	5875
1965	0	0	360	248	570	837	837	924	1147	465	248	60	5696
1966	0	0	60	403	690	992	1054	980	651	600	155	0	5585
1967	0	0	120	372	720	1178	899	840	682	540	434	180	5965
1968	0	0	120	341	810	1023	961	870	744	660	408	0	5937
1969	0	0	30	800	800	961	800	950	1000	450	250	180	6221
1970	0	0	120	496	660	806	992	728	1023	690	186	0	5701
1971	0	0	270	527	780	1023	868	868	713	510	310	0	5869
1972	0	0	90	465	960	1240	1085	754	558	510	248	0	5910
1973	0	0	270	403	810	961	1178	924	930	810	403	0	6689
1974	0	0	180	372	780	1023	1147	784	682	480	124	0	5572
1975	3	31	209	353	791	838	1023	952	899	660	378	131	6268
1976	---	---	---	---	---	---	---	---	---	---	---	---	---
1984	2	7	221	594	678	904	503	748	715	612	258	116	5358
1985	---	---	---	---	---	---	1161	977	513	---	---	---	2651
1986	9	12	166	103	541	954	269	808	557	523	236	49	4229
1987	22	68	164	431	713	1024	967	821	847	431	207	63	5758
1988	27	34	211	390			1093	864	844	485	213	34	4194
1989	8	21	125	481	658	946	895	846	729	554	317	178	5758
1990	70	13	119	411	627	1183	881	919	897	607	415	50	6193
1991	31	26	174	495	894	903	1107	689	780	629	306	76	6107
1992	43	77	92	389	915	1080	914	741	750	415	291	144	5851
1993	28	68	139	550	896	910	1128	1037	796	647	323	162	6685
Mean	27	36	157	427	740	988	892	845	743	545	285	97	5278
Stdev	21	27	42	141	143	101	291	109	124	86	65	54	1224

SITE1.XLS-Table-j-2/9/95

TABLE 2.18. SITE Heating-Degree Days (1964-1977 and 1984-1993).

	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	Seasonal
BASE: 40 F													
Mean	0	0	0	1	47	202	223	164	78	2	0	0	694
Std dev	0	0	0	7	71	127	116	120	106	10	0	0	224
Min	0	0	0	0	0	9	0	0	0	0	0	0	304
Max	0	0	0	32	199	433	394	480	374	49	0	0	1308
BASE: 45 F													
Mean	0	0	0	8	159	352	369	303	194	26	0	0	1358
Std dev	0	0	0	35	103	129	129	119	137	47	0	0	308
Min	0	0	0	0	0	126	49	129	0	0	0	0	770
Max	0	0	0	167	349	583	549	620	529	199	0	0	2095
BASE: 50 F													
Mean	0	0	0	32	298	503	516	443	339	119	3	0	2163
Std dev	0	0	0	71	119	131	145	118	143	89	13	0	409
Min	0	0	0	0	0	241	104	269	107	0	0	0	1466
Max	0	0	0	302	499	734	704	760	684	349	61	0	3000
BASE: 55 F													
Mean	0	0	2	124	443	653	662	582	487	260	33	0	3114
Std dev	0	0	11	105	124	135	165	117	148	95	55	0	534
Min	0	0	0	0	122	356	159	409	262	108	0	0	1861
Max	0	0	54	437	649	889	859	900	839	499	216	0	3947
BASE: 60 F													
Mean	0	0	27	264	590	804	808	722	634	405	146	2	4218
Std dev	0	0	51	116	126	139	187	116	156	97	91	7	701
Min	0	0	0	73	272	471	214	549	413	258	0	0	2256
Max	0	0	204	572	799	1044	1014	1040	994	649	371	33	5125
BASE: 65 F													
Mean	0	0	130	408	736	954	954	861	781	550	293	48	5475
Std dev	0	0	81	129	128	144	211	116	165	99	99	62	890
Min	0	0	0	73	272	471	214	549	413	258	0	0	2651
Max	0	0	354	707	949	1199	1169	1180	1149	799	526	183	6507
BASE: 70 F													
Mean	25	46	269	551	883	1105	1101	1001	929	694	442	161	6899
Std dev	39	45	85	147	132	150	236	116	176	103	105	96	1130
Min	0	0	136	133	572	701	324	829	613	548	270	0	3046
Max	118	144	504	842	1099	1354	1324	1320	1304	949	681	333	8167
BASE: 75 F													
Mean	140	185	408	694	1029	1255	1247	1141	1076	839	591	304	8522
Std dev	80	66	92	168	136	156	262	116	188	107	113	101	1406
Min	0	61	286	163	722	816	379	969	713	663	404	96	3441
Max	273	299	654	977	1249	1509	1479	1460	1459	1099	836	483	9917

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2.3.7 Growing-Season Data

Means and extremes of early- and late-season cold temperature occurrences were calculated from the historical Site temperature data bases (1953-1977 and 1984-1993). The calculations were based on temperatures of 36°F, 32°F, 28°F, and 24°F (Table 2.19). The average spring and fall dates were calculated by averaging the Julian date for the specified cold temperature occurrences for each year. The extreme dates were determined from a query of the data base using the specified temperatures and an algorithm that looked for the earliest spring date and latest fall date. Because the temperatures are measured at various heights at the different locations, ground temperatures will vary in relation to the measured temperatures under some weather conditions. For example, a 36°F low temperature indicates a light frost because actual ground temperatures may approach 32°F under clear skies and light winds. Also because the temperature sensor was located on a rooftop until April 1975, the actual ground temperature may exceed the measured temperatures. A 32°F low temperature is defined as a freeze; a 28°F low temperature represents a hard freeze. The difference between 28°F and 32°F is enough to affect plants differently. A low temperature of 32°F may have little effect on fruit trees (elevated above ground), whereas plants near the ground may be heavily damaged because ground-level temperatures or temperatures in local low spots may be several degrees colder than the indicated temperatures. A 28°F low temperature, however, may be cold enough to damage plants, such as fruit trees, well above the ground.

TABLE 2.19. SITE Growing-Season Data (1953-1977, 1984-1993).

Temperature (Degree F)	Means: Average Spring Date	Means: Average Fall Date	Means: No. of Days Between Dates
36	5/16	10/01	138
32	4/27	10/10	166
28	4/15	10/16	184
24	3/28	10/29	215
20	3/25	11/7	227
16	3/12	11/15	248

Temperature (Degree F)	Extremes: Spring Date Earliest	Spring Date Latest	Fall Date Earliest	Fall Date Latest	No. of Days Between Dates Least	No. of Days Between Dates Most
36	1/1/90,91,69	06/14/69	9/12/74	12/31/70	110(69)	170 (87)
32	1/1/90,91,64	05/14/67	9/16/65,71	12/31/70	130(65)	216 (86)
28	1/1/90,91,64	05/12/66	9/16/65	12/31/1970,84,86	154(66)	220 (86)
24	1/1/90,91,64	04/23/68	9/19/71	12/31/1970,86,91	167(71)	261(65)
20	2/20/86	04/20/66	10/11/69	02/06/86	197(91)	337(85)
16	1/08/70	04/20/66	10/12/69	02/07/86	218(89)	338(85)

2.3.8 Freeze-Thaw Days

Freeze-thaw days are defined as days in which the maximum temperature is greater than 32°F and the minimum temperature is 32°F or lower. The change in temperatures from above freezing to below freezing is stressful to materials such as concrete and asphalt. In fact, damage to roads and highways increases with frequent freezing and thawing.

Table 2.20 was based on the 1964-1977 and 1984-1993 data sets. Daily temperature data were not available before 1964. It should be noted that the placement of the temperature sensor on a rooftop (before May 1975) caused more freeze-thaw days to be reported than after the monitoring station was moved to the West Buffer Zone.

TABLE 2.20. Site Freeze-Thaw Days (1964-1977, 1984-1993).

Month	Number of Freeze-Thaw Days			
	Maximum on Record	Minimum on Record	MEAN	Standard Deviation
January	23	4	14.5	5.0
Febuary	23	8	15.0	4.6
March	25	8	13.7	4.2
April	18	2	8.5	4.5
May	7	1	2.2	1.7
June	0	0	0.0	0.0
July	0	0	0.0	0.0
August	0	0	0.0	0.0
September	6	3	4.3	1.5
October	12	1	4.8	3.1
November	20	1	12.5	4.1
December	23	7	16.4	4.8

2.3.9 Extreme Apparent Temperatures

Apparent temperature incorporates primarily temperature, together with wind speed and atmospheric humidity, to gauge the relative weather effects on the human body. Greater wind speeds increase the amount of heat removed from an exposed body, thereby lowering apparent temperature; greater atmospheric moisture lowers evaporation, thereby increasing apparent temperature. Apparent temperature can also be affected by sunshine intensity.

Apparent temperature is a convenient comfort indicator because it can be compared between winter and summer. The National Weather Service routinely reports apparent temperatures during the summer; the wind-chill factor is commonly used in the winter. As stated, the apparent temperature includes the effects of both wind and moisture. In practice, calculated mean apparent temperatures are usually similar to calculated mean wind-chill values.

Apparent temperatures were calculated from 15-minute-averaged temperatures measured during January and July, the two months with the most extreme temperatures. A simplified equation, suggested by Steadman (1984), was used to determine apparent temperature in the shade:

$$At_{ue} = -2.7 + 1.04T + 0.2e - 0.65u$$

Where:

At_{ue} = apparent temperature (°C)
T = temperature (°C)
e = vapor pressure (mbar)
u = near-surface wind speed (m/s)

The 15-minute-averaged vapor pressure was calculated from the relationship between relative humidity and the saturation vapor pressure:

$$e = e_s * (RH)$$

Where:

e = vapor pressure (mbar)
e_s = saturation vapor pressure (mbar)
RH = relative humidity (%)

The e_s term is simply dependent on temperature. The following expression from the Handbook of Meteorology (Berry, Bollay and Beers, 1945) was used to calculate e_s:

$$\ln e_s = 25*(T-273)/T - 5.2*\ln(T/273) + \ln 6.105,$$

Where:

T = absolute temperature (°K)

Additionally, apparent temperature was calculated for exposure in the sun. A slightly different equation also suggested by Steadman (1984) was used as follows:

$$AT_{uei} = 4.5 + 1.02T - 02.8e - 1.00u - 5.8\phi + 0.0054i$$

Where:

At_{uei} = apparent temperature (°C)
T = temperature (°C)
u = near surface wind speed (m/s)
e = barometric pressure (kPa)
u = wind speed (m/s)
ϕ = fraction of solar radiation on horizontal surface, that is direct
i = heat-transfer rate per unit area of horizontal surface (W/m^2)

The third, fifth, and sixth terms were eliminated from the calculations since they contributed less than one percent to the answer.

Tables 2.21 and 2.22 present the cumulative probability of occurrence for apparent temperatures in addition to the mean maximum and minimum and average values. The cumulative probabilities are the temperatures that correspond to the given percentile on the apparent temperature distribution. For example, in Table 2.21, -2°C represents the fifth percentile on the apparent temperature distribution, while in Table 2.22, 79°C represents the 95th percentile.

Tables 2.21 and 2.22 were based on the 1984-1993 data set only. Hourly data were not available before 1984. The apparent temperatures in this analysis are representative of the West Buffer Zone location. See Section 1.4 for a discussion of data quality.

TABLE 2.21. January Extreme and Mean Apparent Temperatures at SITE (1984-1993).

JANUARY		Low	0.1%	0.2%	0.5%	1%	2%	5%
Shade (Degree F)		-20	-17	-16	-14	-12	-8	-2
Mean maximum	48							
Mean minimum	-9							
Average	20							
Sun (Degree F)		-6	-5	-5	-2	0	4	11
Mean maximum	39							

TABLE 2.22. July Extreme and Mean Apparent Temperatures at SITE (1984-1993).

JULY		5%	2%	1%	0.5%	0.2%	0.1%	High
Shade (Degree F)		79	82	84	85	87	88	91
Mean maximum	86							
Mean minimum	42							
Average	64							
Sun (Degree F)		90	93	96	98	99	100	101
Mean maximum	82							

2.3.10 Wind-Chill-Equivalent Temperatures

Wind-chill-equivalent temperatures were calculated using the following equation:

$$W\text{-}C\text{-}E = 91.4 + A\,(\,(.04538 * T) - 4.148)$$

Where:

$A = 6.686 \cdot \sqrt{V} - (.447 \cdot V) + 10.45$

V = wind speed (miles/hr)

T = temperature

Table 2.23 presents the cumulative probability of occurrence for extreme wind-chill-equivalent temperatures in addition to the mean maximum and minimum and average values. The cumulative probabilities are the temperatures that correspond to the given percentile on the wind-chill-equivalent temperature distribution. For example, -10°C is the temperature at the fifth percentile.

Table 2.23 was based on the 1984-1993 data set only. Hourly data were not available before 1984. Wind-chill equivalent temperatures are representative of the West Buffer Zone location. See Section 1.4 for a discussion on data quality.

TABLE 2.23. January Extreme and Mean Wind-Chill-Equivalent Temperatures at SITE (1984-1993).

JANUARY		Low	0.1%	0.2%	0.5%	1%	2%	5%
Temperature (F)		-36	-32	-29	-24	-21	-16	-10
Mean maximum	51							
Mean minimum	-19							
Average	16							

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2.3.11 Daily Mean High and Low Temperatures

Table 2.24 was based on the 1964-1977 and 1984-1993 data sets only. Daily temperature data were not available before 1964. This analysis is based on a combination of data collected at Building 123 and in the West Buffer Zone. See the discussions on temperature data quality in Sections 1.3.2 and 1.4.

TABLE 2.24. SITE Daily Mean High and Low Temperatures (Degree F) (1964-1977,1984-1993).

	Jan.		Feb.		Mar.		Apr.		May		June		July		Aug.		Sept.		Oct.		Nov.		Dec.	
Date	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L
1	37	20	41	25	50	31	50	31	58	38	66	48	82	59	79	60	74	56	71	49	49	32	44	28
2	37	18	41	24	46	28	52	32	60	40	70	49	82	60	78	60	75	57	70	49	47	30	45	27
3	33	16	42	25	41	23	46	32	61	42	72	52	82	60	75	58	75	55	65	45	45	32	45	27
4	38	19	43	24	40	24	50	32	64	44	70	51	81	60	79	58	75	54	65	47	49	33	47	30
5	37	22	42	23	45	25	55	36	61	43	71	52	83	61	80	60	76	55	63	46	51	32	45	26
6	37	19	39	22	47	29	59	37	59	42	72	53	85	62	81	60	79	57	63	44	51	35	43	26
7	37	20	41	23	46	27	55	37	61	43	73	54	83	61	79	61	76	56	63	44	54	35	46	28
8	35	18	40	23	49	30	54	35	61	42	68	52	80	61	79	60	76	54	62	44	51	35	46	28
9	36	20	46	25	48	30	55	35	61	43	69	51	82	60	79	60	74	54	62	43	52	35	45	30
10	42	24	43	27	46	31	57	36	64	44	71	51	82	60	81	60	72	55	64	44	52	36	44	28
11	42	21	43	25	47	30	55	38	62	43	71	53	81	60	81	61	73	51	64	44	53	37	47	27
12	40	21	45	28	46	29	54	36	63	43	73	54	79	59	78	60	71	52	65	45	54	38	38	24
13	44	26	44	26	49	30	53	34	65	45	73	54	81	59	80	59	71	53	66	44	53	35	37	22
14	43	25	40	22	47	30	57	35	66	48	72	53	81	62	80	60	70	51	59	38	49	33	39	21
15	45	25	39	21	46	31	59	39	67	47	74	53	80	61	80	58	66	51	58	39	49	33	39	24
16	45	27	40	24	50	31	60	40	65	46	74	54	83	61	81	60	66	49	57	38	48	33	44	23
17	42	26	40	24	48	30	56	37	68	47	74	55	81	61	80	60	67	48	58	40	47	31	40	24
18	41	24	42	25	47	28	55	35	68	50	74	54	81	62	79	60	67	48	53	36	45	29	41	22
19	42	23	44	28	47	30	53	37	69	49	78	55	78	59	80	60	67	49	58	37	47	31	40	23
20	43	26	42	26	47	30	54	38	69	49	78	57	77	58	78	59	69	50	60	39	51	32	40	23
21	43	27	42	25	53	31	58	37	69	50	77	56	80	60	77	58	66	48	63	42	50	33	40	23
22	42	27	44	24	50	31	59	40	65	49	78	57	80	60	77	58	65	46	60	44	47	31	41	23
23	43	26	42	24	46	29	59	42	67	49	77	56	80	60	77	57	69	48	59	41	45	28	41	24
24	41	26	46	28	47	29	59	40	67	48	78	56	78	59	78	57	68	49	57	39	48	32	41	23
25	40	25	46	29	48	30	57	39	67	48	79	57	80	59	79	58	68	50	59	40	48	28	41	23
26	44	25	46	27	54	32	54	38	67	47	79	58	81	61	79	60	67	47	58	40	41	25	41	25
27	44	27	46	29	51	32	54	37	65	48	84	59	81	60	77	58	66	46	57	37	40	22	41	23
28	45	27	50	31	46	29	59	38	67	49	83	61	82	60	81	59	64	46	55	35	43	26	42	24
29	44	26	58	35	48	29	57	38	67	49	81	61	80	60	78	58	66	46	52	35	44	27	39	22
30	47	28			51	31	56	38	65	49	80	59	80	61	76	56	69	49	52	34	46	27	39	19
31	46	27			52	32			64	48			79	60	76	56			52	35			38	19

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2.4 PRECIPITATION

2.4.1 Building 771/Buffer Zone Data Comparison

The data collected in the manual Clear-Vu rain gauge located on the roof of Building 771 were compared with the rain data collected at the Buffer Zone Site (Table 2.25). Building 771 data were collected between July 1976 and December 1988. Data overlap occurred during 1984 to 1988 only. Yearly and monthly averages for the Building 771 data were computed for the entire period 1976-1988 and 1984-1988, the years of data overlap. It should be noted that the computed annual average for 1976-1988 (14.82") differs from the annual average, which is the sum of the monthly averages for the same period (15.49"). The difference is due to 1976 being a partial year with data collection beginning on July 1. Differences between the Building 771 and Buffer Zone Data are apparent and are owing to missing data in the Buffer Zone data set.

TABLE 2.25. Building 771 / West Buffer Zone Precipitation Data Comparison

Year	Total Rainfall Clear-Vu Data (1984-1988)	Clear-Vu Data (1976-1988)	Buffer Zone Data (1984-1988)
1976		8.58	
1977		9.15	
1978		15.23	
1979		19.13	
1980		12.61	
1981		13.24	
1982		19.89	
1983		21.89	
1984	11.32	11.32	6.82
1985	14.23	14.23	0.53
1986	20.97	20.97	9.10
1987	17.14	17.14	11.13
1988	9.31	9.31	10.32
Average	14.59	14.82	7.58

Month	Average Rainfall Clear-Vu Data (1984-1988)	Clear-Vu Data (1976-1988)	Buffer Zone Data (1984-1988)
January	0.31	0.31	0.08
February	0.76	0.47	0.35
March	0.70	1.10	0.60
April	1.34	1.72	1.05
May	1.97	3.08	1.82
June	2.31	2.02	1.34
July	1.89	1.55	1.19
August	1.60	1.88	1.54
September	0.93	1.09	0.66
October	1.24	0.92	1.76
November	0.86	0.80	0.47
December	0.70	0.56	0.15
Total	14.59	15.49	11.02

2.4.2 Monthly Mean

Table 2.26 presents the Site monthly and annual precipitation means and medians (also see Figure 2.2). The analyses were based on the 1953-1977 and 1987-1993 data sets. 1984-1986 data were eliminated due to the data covering only part of each of these years.

Table 2.26. SITE Monthly and Annual Precipitation Means and Medians (1953-1977, 1987-1993).

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Mean Precipitation (in.)													
SITE	0.46	0.57	1.27	1.56	2.68	1.56	1.46	1.30	1.50	0.90	0.83	0.47	14.46
Median Precipitation (in.)													
SITE	0.31	0.54	0.94	1.25	2.07	1.17	1.26	1.22	1.26	0.53	0.82	0.37	13.51

2.4.3 Hourly Precipitation Means and Frequencies

Figures 2.9(a)-(d) were based on the 1984-1993 data set only and do not include Denver data for comparison. Hourly precipitation data were not available before 1984 and Denver data were not available. It should be noted that the January 0600 value might be a result of snow accumulated in the rain gauge funnel that melts when the sun rises (see Figures 2.9a and b).

FIGURE 2.9. Hourly Precipitation Amounts and Frequencies at SITE During (a) January, (b) April, (c) July, (d) October (1984-1993).

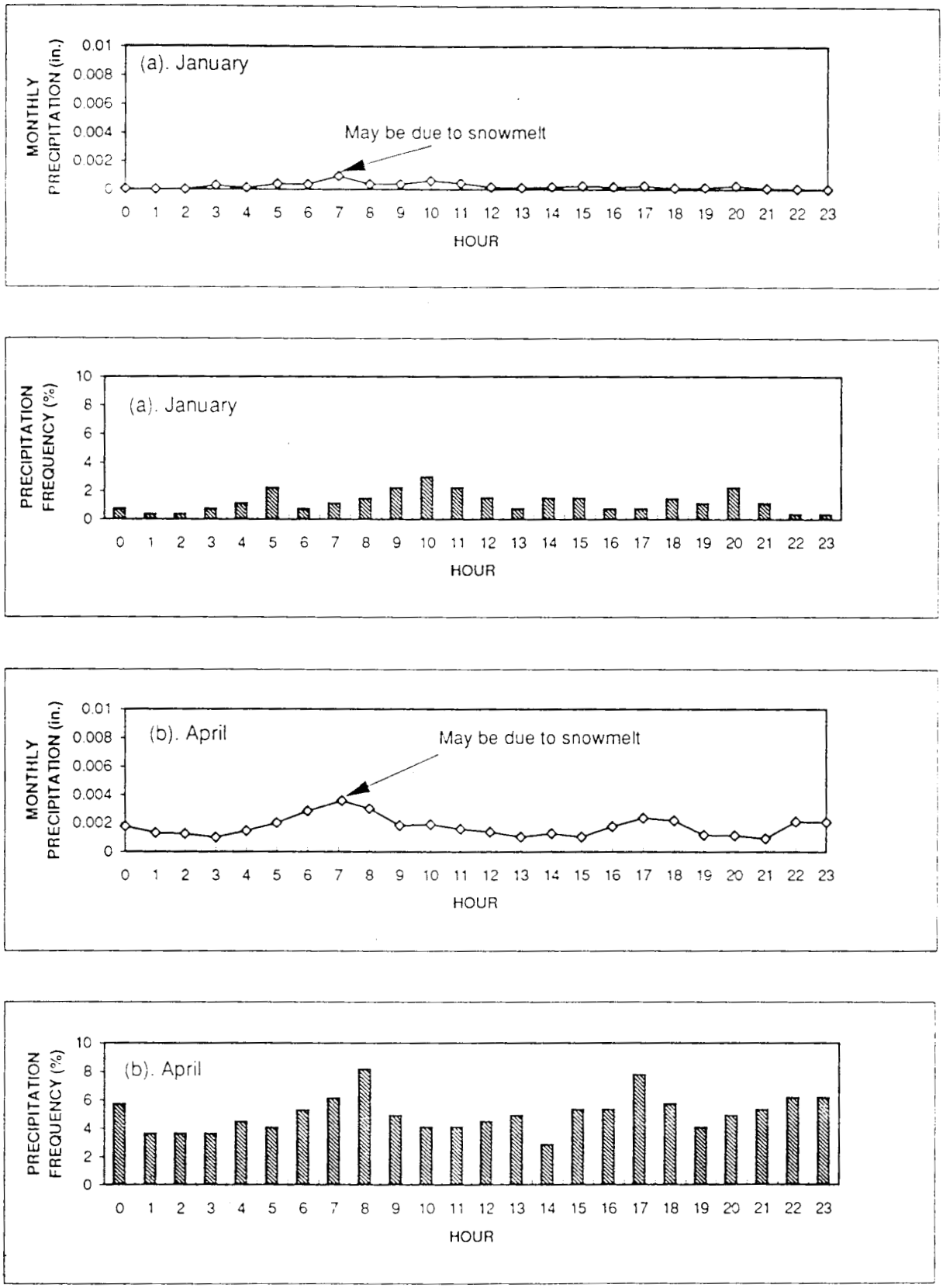
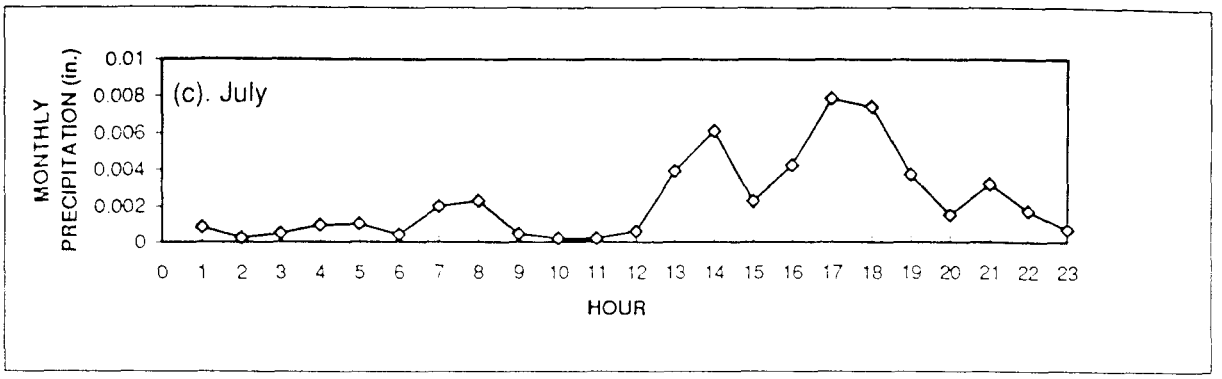
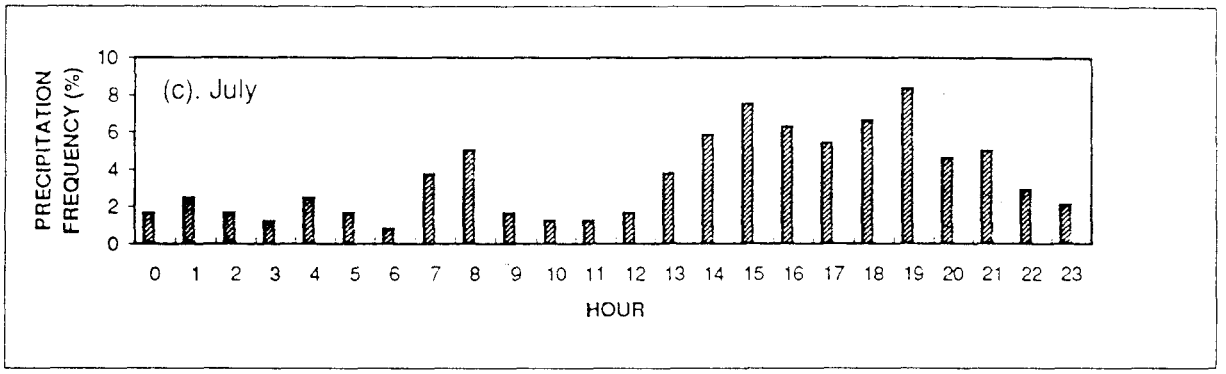
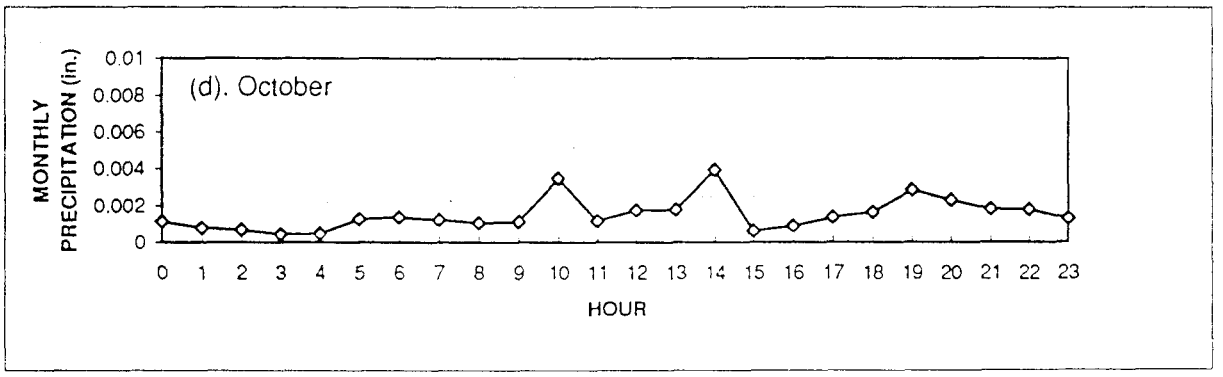
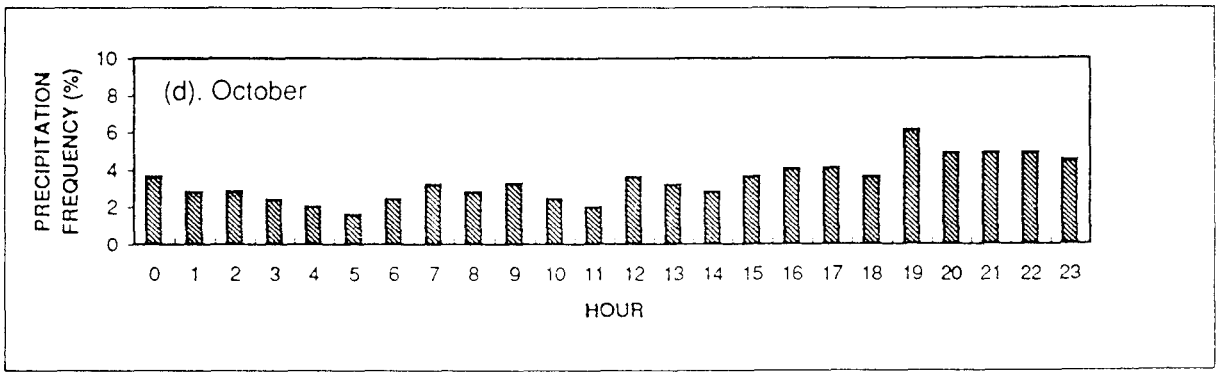


FIGURE 2.9. (Continued).









2.4.4 Precipitation Probabilities

The precipitation probabilities presented in Table 2.27 are the precipitation amounts that correspond to the given percentages as they occur on the precipitation distributions for each month, annually and seasonally. For example, 0.31" is the precipitation amount that occurs at the 50th percentile for the January precipitation distribution. The analysis is based on the entire 1953-1977 and 1984-1993 data sets with the exception of years 1984-1986. Data collected during these years were not complete and would have skewed the results.

TABLE 2.27. Monthly SITE Precipitation Probabilities (1953-1977,1987-1993).

	LOW	5%	10%	25%	50%	75%	90%	95%	HIGH
Precipitation (in.)									
JAN	0.03	0.06	0.15	0.23	0.31	0.54	1.05	1.09	1.73
FEB	0.00	0.04	0.07	0.17	0.53	0.84	1.11	1.28	1.81
MAR	0.13	0.14	0.41	0.71	0.94	1.61	2.30	3.36	4.20
APR	0.10	0.15	0.34	0.98	1.25	1.80	3.10	3.78	4.73
MAY	0.08	0.55	0.72	1.25	2.07	3.49	4.71	5.97	9.70
JUN	0.12	0.22	0.31	0.66	1.17	1.86	3.07	3.41	4.79
JUL	0.30	0.43	0.48	0.71	1.26	1.72	2.47	2.60	5.10
AUG	0.10	0.20	0.22	0.42	1.22	2.03	2.47	2.90	3.69
SEP	0.00	0.00	0.03	0.45	1.26	2.15	3.05	3.17	4.53
OCT	0.03	0.05	0.06	0.30	0.53	0.91	1.89	1.91	4.83
NOV	0.12	0.15	0.17	0.43	0.81	1.13	1.50	1.70	2.00
DEC	0.02	0.09	0.11	0.18	0.35	0.54	1.05	1.45	1.50
Annual	7.76	8.06	8.93	11.03	13.43	16.67	21.36	22.60	25.72
Winter	0.40	0.41	0.45	0.85	1.39	1.86	2.52	2.63	3.65
Spring	1.87	1.97	2.27	3.44	4.88	6.71	8.41	11.49	12.07
Summer	1.34	1.54	1.96	2.72	3.96	5.45	6.26	8.02	9.16
Fall	0.78	0.82	1.19	1.82	2.92	4.37	5.64	5.90	6.56

2.4.5 Specified Daily Precipitation Amounts

Table 2.28 presents the mean and maximum number of days, by month and annually, that the specified precipitation amounts (0.01", 0.05", ..., 1.0") occur. The analysis was based on the 1964-1977 and 1984-1994 data sets. Daily data were not available before 1964. Data collected during 1984-1986 were eliminated from the analysis because of missing data that would have skewed the results.

TABLE 2.28. Mean Number of Days of Precipitation for Specified Amounts, Maximum Number of Days in Which Precipitation Exceeded the Specified Amount, and Latest Year the Maximum Occurred (1964-1977, 1984-1993).

	0.01 in			0.05 in			0.1 in			0.25 in		
Month	Mean	Max	Yr of Max	Mean	Max	Yr of Max	Mean	Max	Yr of Max	Mean	Max	Yr of Max
JAN	4	7	1987	2	5	1974	2	3	1974	2	3	1973
FEB	4	9	1971	3	5	1974	2	4	1968	1	2	1974
MAR	7	12	1970	5	12	1970	4	11	1970	2	7	1970
APR	7	13	1990	6	12	1973	4	12	1973	3	10	1973
MAY	8	14	1992	6	10	1967	5	9	1969	4	7	1969
JUN	8	16	1965	6	12	1967	4	10	1969	3	8	1969
JUL	9	17	1990	6	12	1965	4	10	1965	2	8	1965
AUG	8	14	1991	5	7	1989	4	7	1987	2	6	1987
SEP	7	13	1990	5	11	1973	4	7	1989	3	5	1976
OCT	5	11	1993	4	11	1969	3	10	1969	2	7	1969
NOV	5	12	1970	4	11	1970	3	5	1991	2	3	1991
DEC	4	7	1967	3	7	1967	2	6	1967	2	3	1973
Annual	76	92	1990	55	73	1973	41	55	1973	27	36	1973

	0.5 in			0.75 in			1.0 in		
Month	Mean	Max	Yr of Max	Mean	Max	Yr of Max	Mean	Max	Yr of Max
JAN	1	1	1974	-	-	-	-	-	-
FEB	1	1	1975	-	-	-	-	-	-
MAR	2	4	1970	2	2	1992	2	2	1992
APR	2	5	1973	1	2	1971	1	1	1986
MAY	2	5	1969	2	4	1969	2	4	1969
JUN	2	4	1969	1	2	1987	1	1	1993
JUL	2	5	1965	1	3	1965	1	1	1986
AUG	1	2	1991	1	2	1967	1	1	1992
SEP	2	4	1970	1	2	1976	1	1	1976
OCT	2	5	1969	2	3	1969	2	2	1984
NOV	1	3	1972	1	1	1972	-	-	-
DEC	1	1	1973	-	-	-	-	-	-
Annual	19	14	1973	13	9	1969	10	5	1969

2.5 WIND

2.5.1 Wind Roses

Wind roses graphically display the frequency of the wind by direction and speed. Figures 2.10 through 2.14 present the breakdown of the average wind frequency for the entire year and for January (Winter), April (Spring), July (Summer) and October (Fall) broken down by day and night and for a complete diurnal period. The analyses were based on the 1984-1993 data set only. Hourly wind data were not available before 1984.

FIGURE 2.10. Annual Day, Night and Total Wind Roses at Site at 10 Meters.

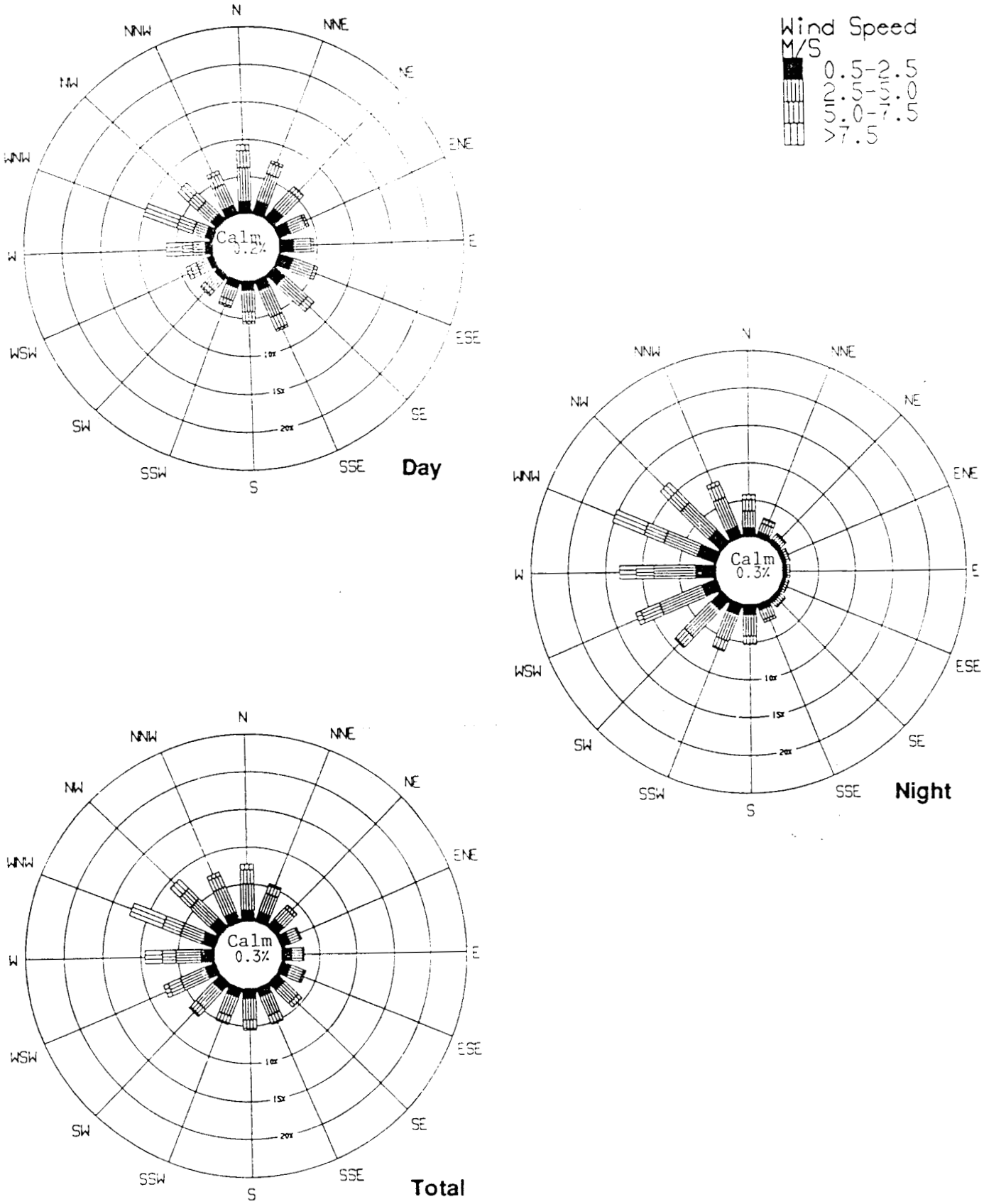


FIGURE 2.11. January Day, Night and Total Wind Roses at Site.

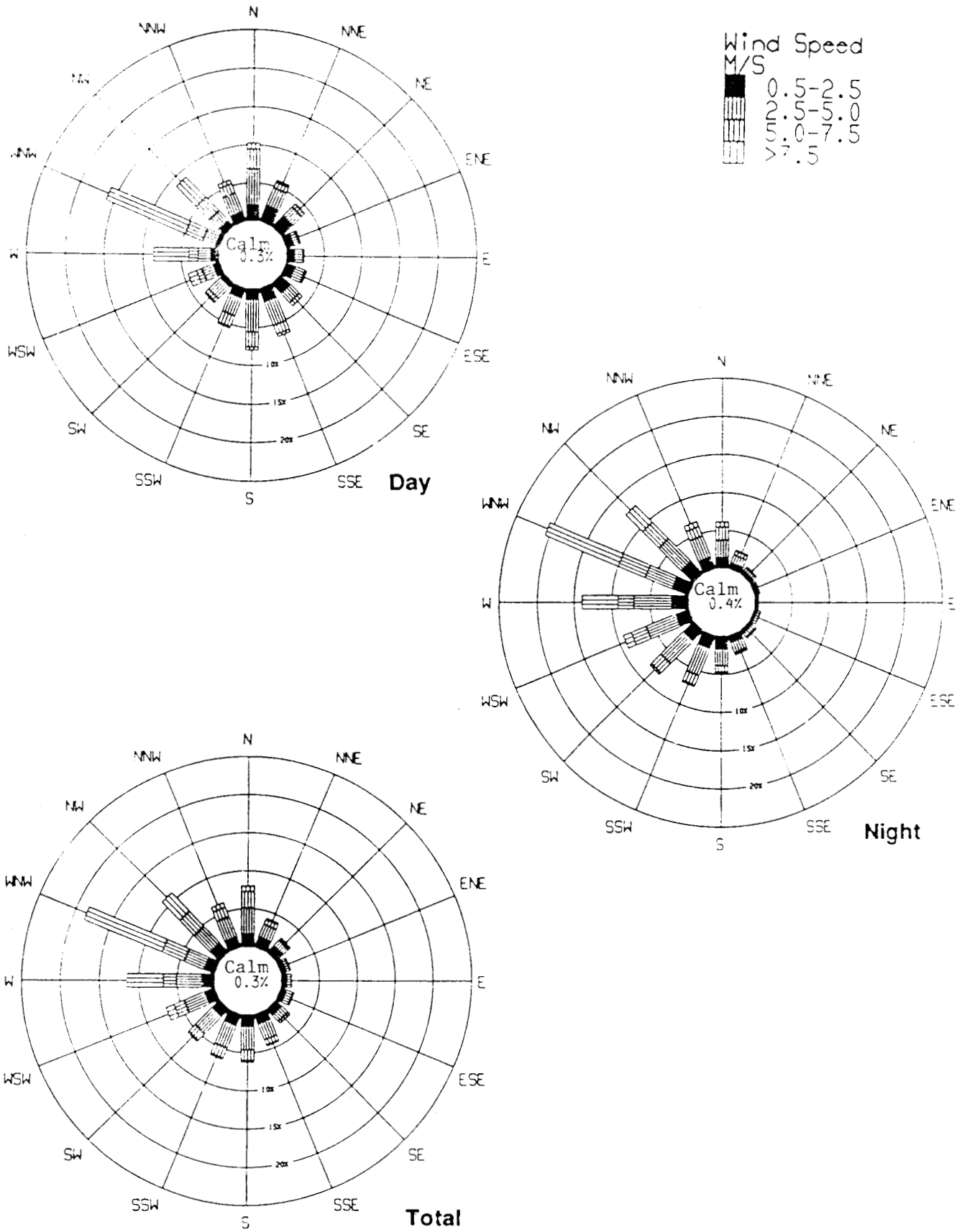


FIGURE 2.12. April Day, Night and Total Wind Roses at Site.

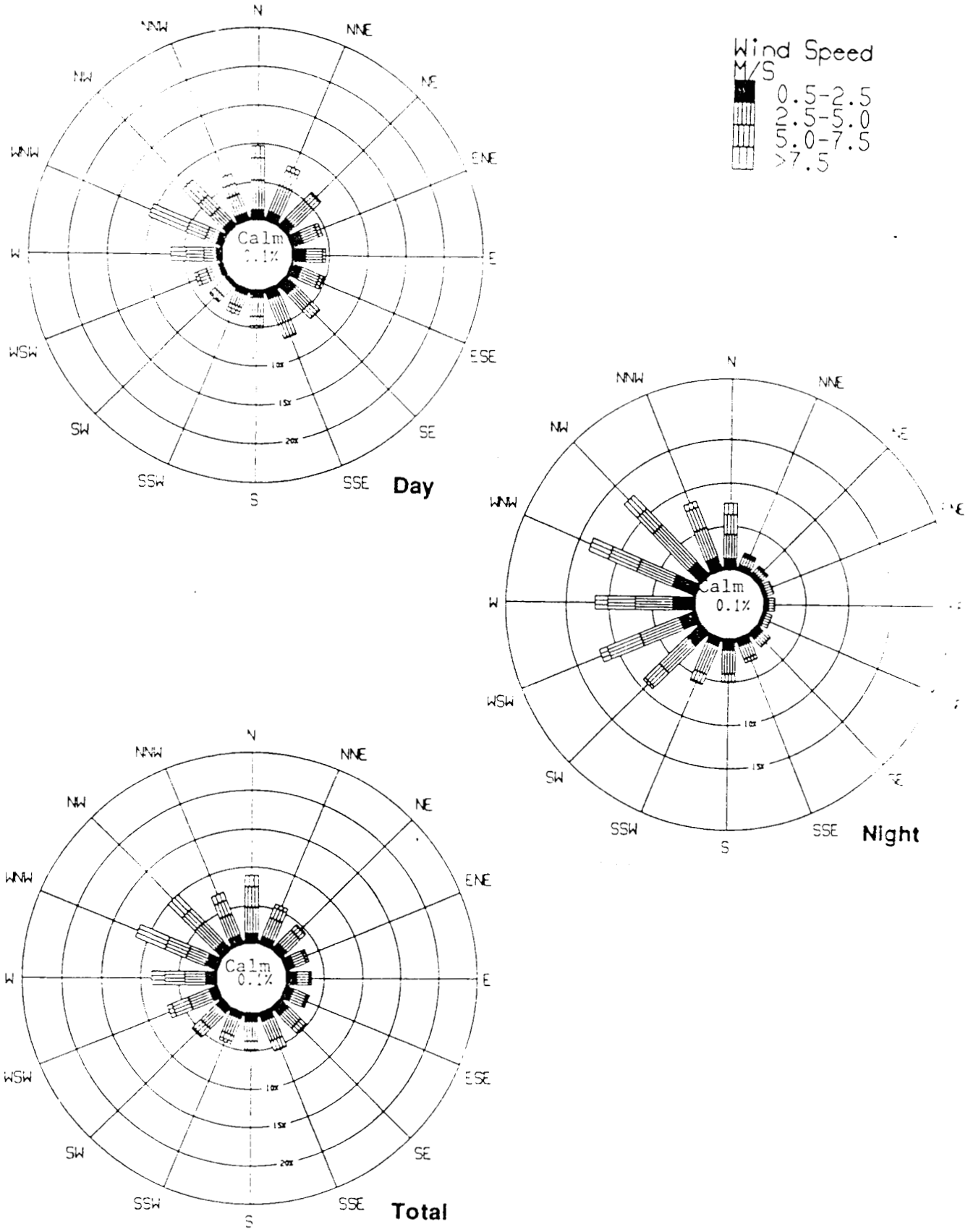


FIGURE 2.13. July Day, Night and Total Wind Roses at Site.

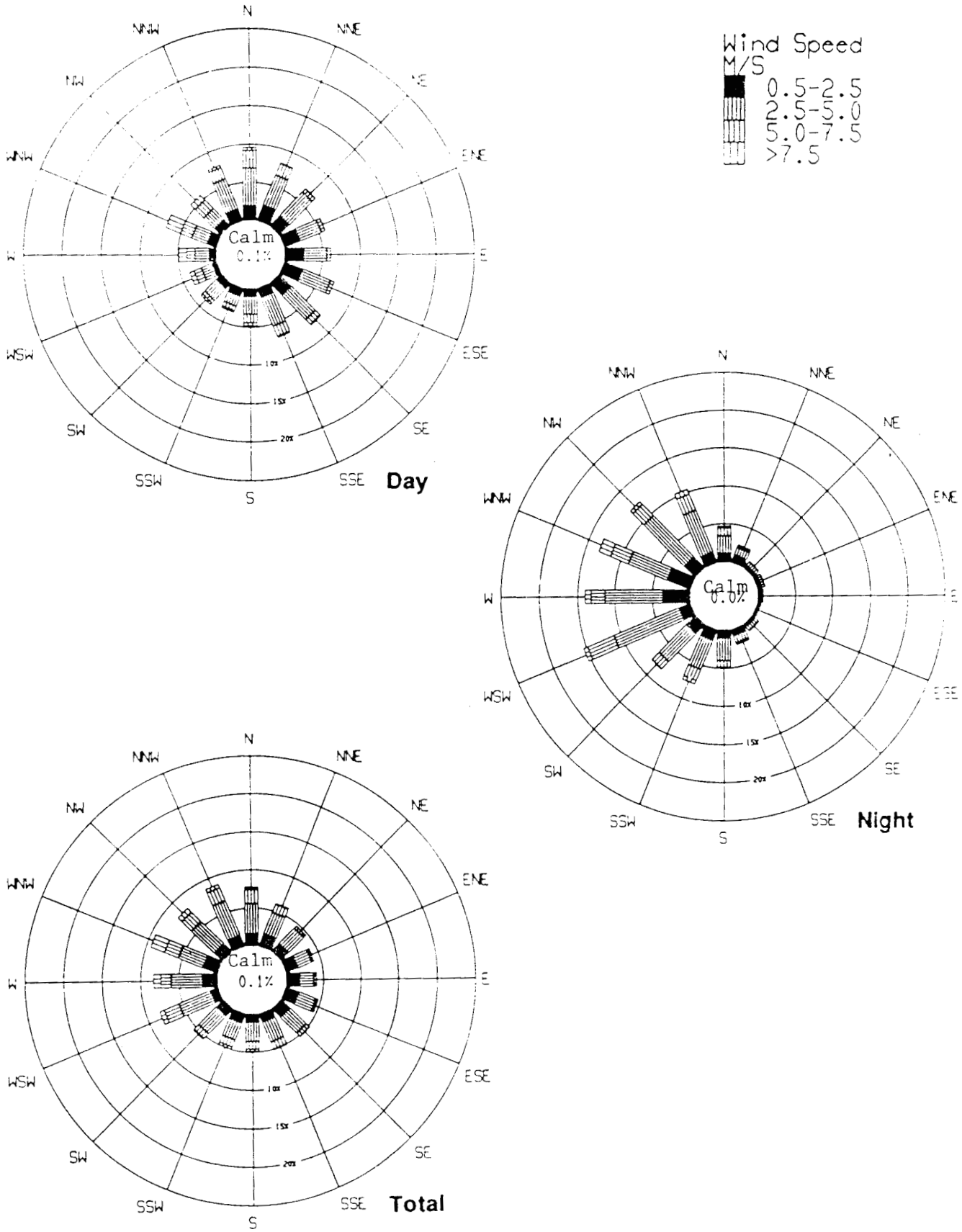
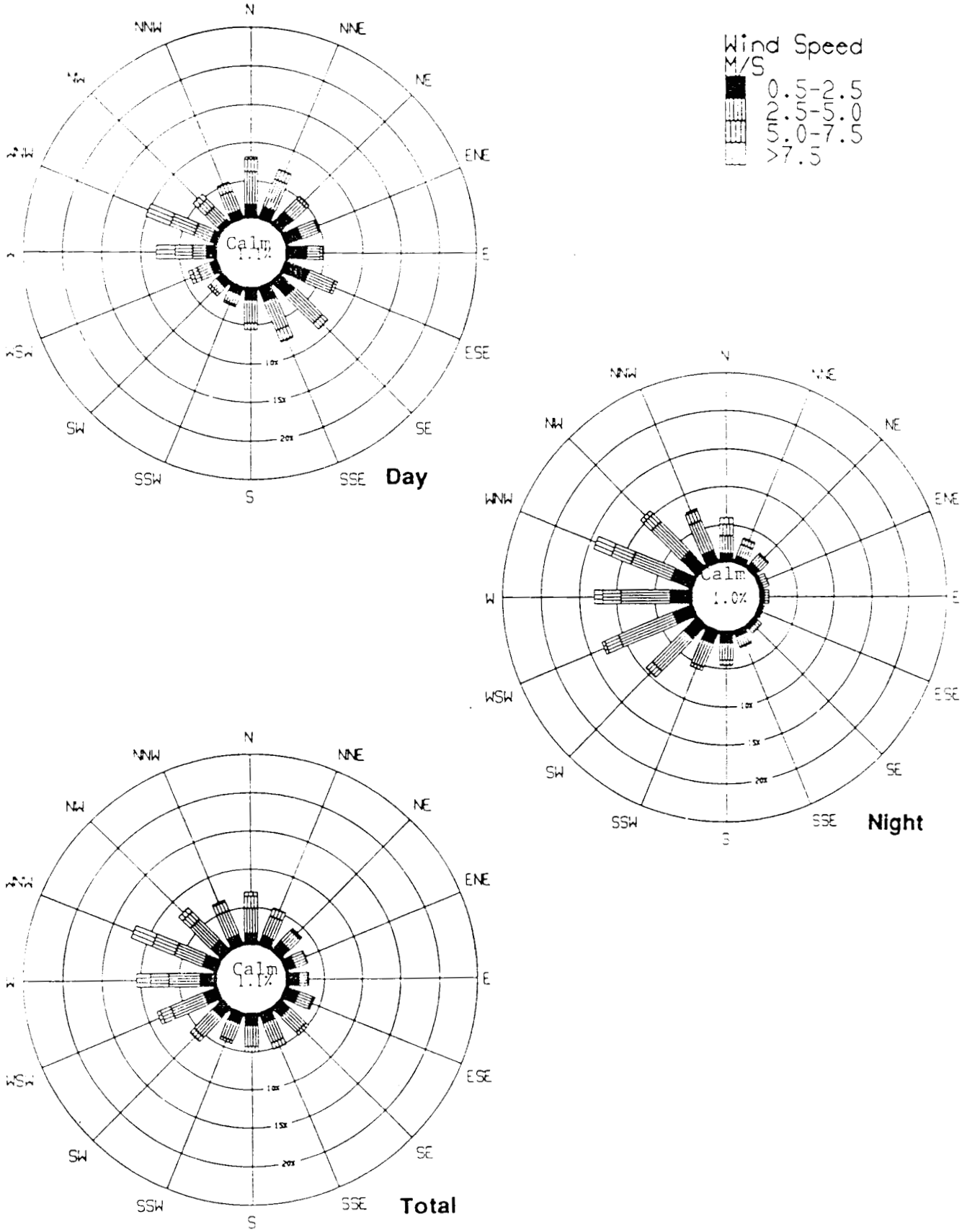


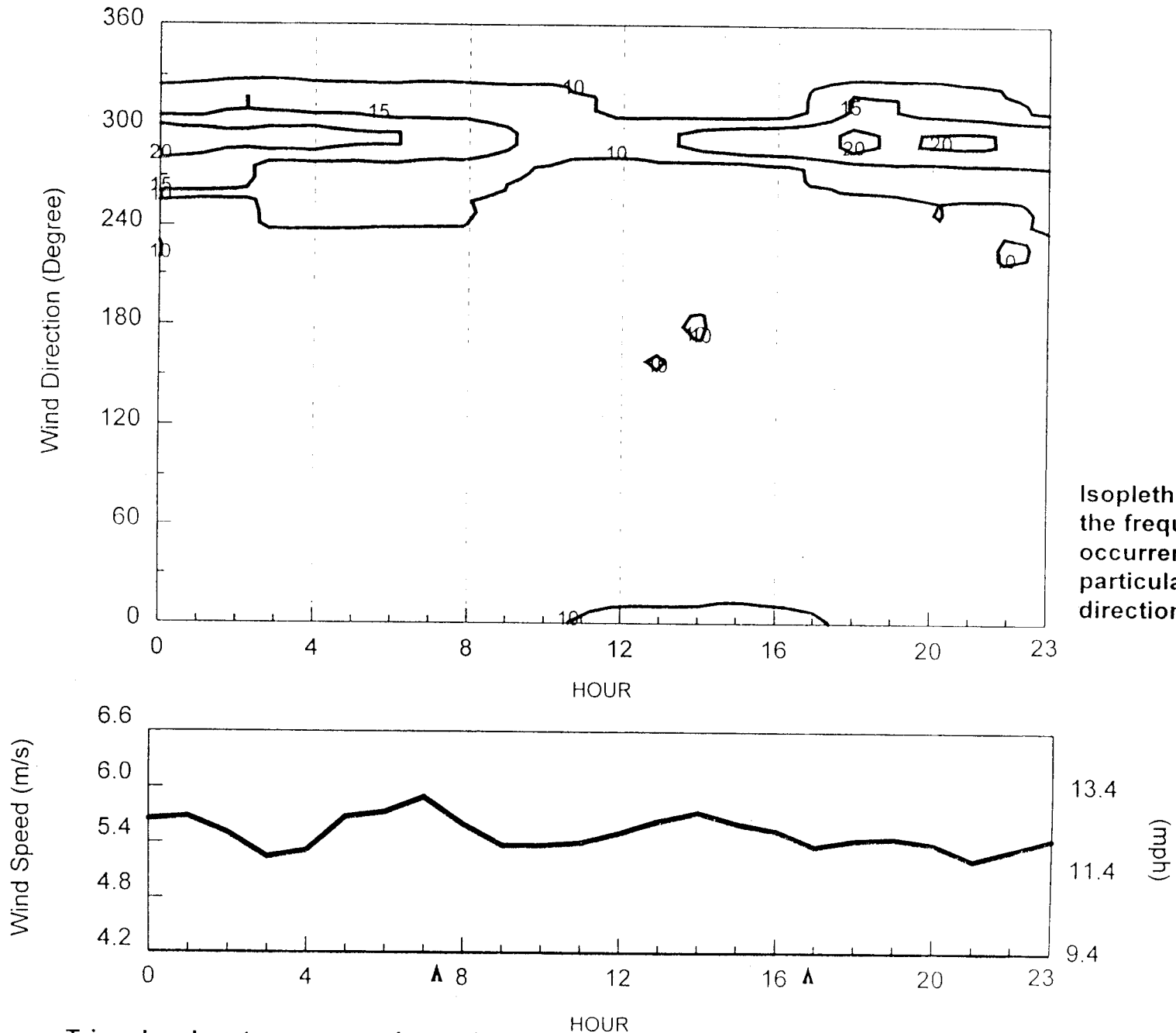
FIGURE 2.14. October Day, Night and Total Wind Roses at Site.



2.5.2 Mean Wind-Direction Frequencies and Wind Speeds

Hourly wind direction frequency diagrams present the distribution of wind directions for a particular time. For example, in Figure 2.15 at 1700 hours, the prevailing wind direction is approximately 295°, varying from approximately 270° (that occurs 10% of the time) to 330° (that also occurs 10% of the time). The analyses presented in Figures 2.15 through 2.22 were based on the 1984-1993 data set only. Hourly wind data were not available before 1984.

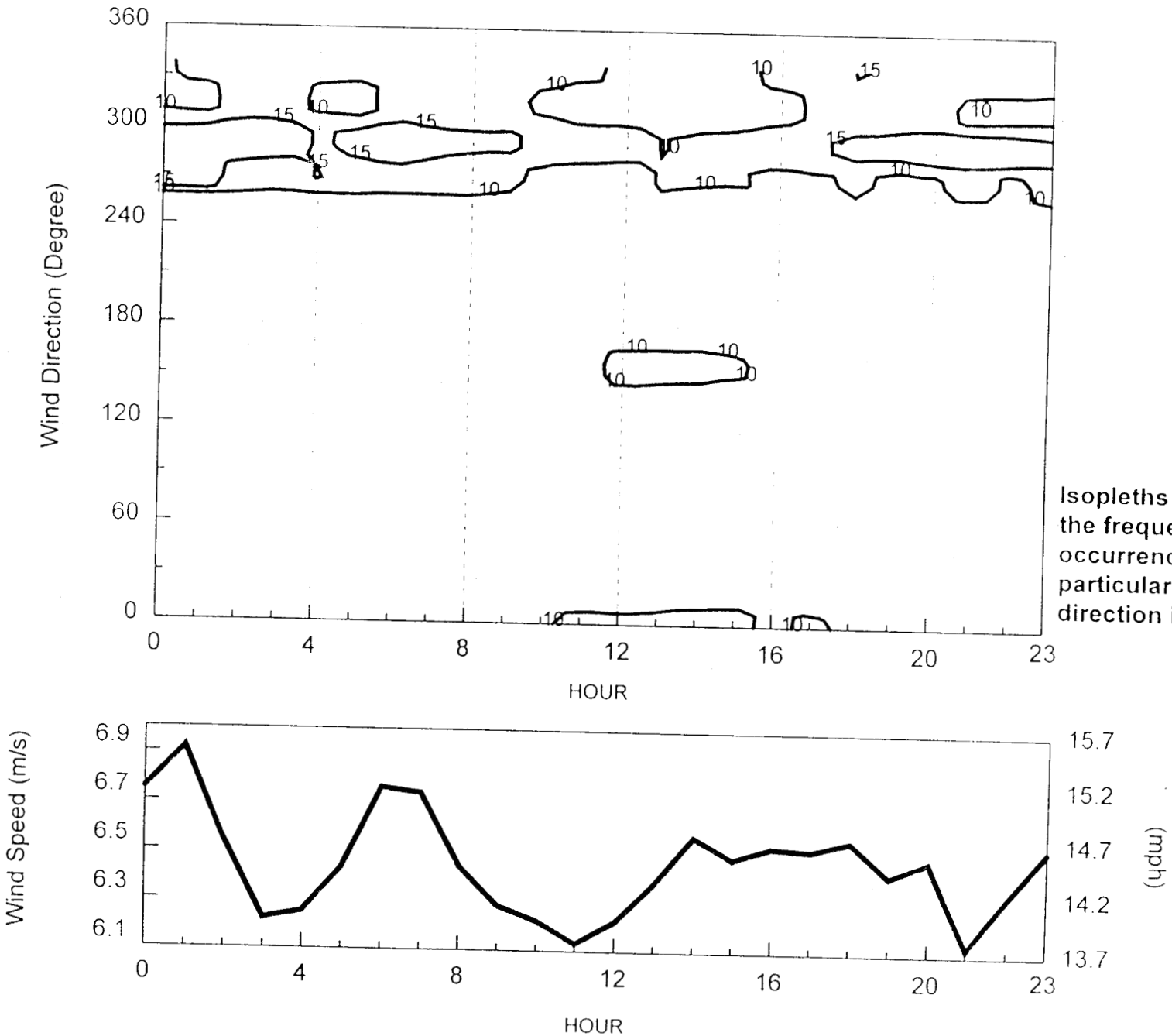
FIGURE 2.15. January Hourly Wind-Direction Frequencies and Wind Speeds at 10 Meters.



Isopleths denote the frequency of occurrence of a particular wind-direction in percent.

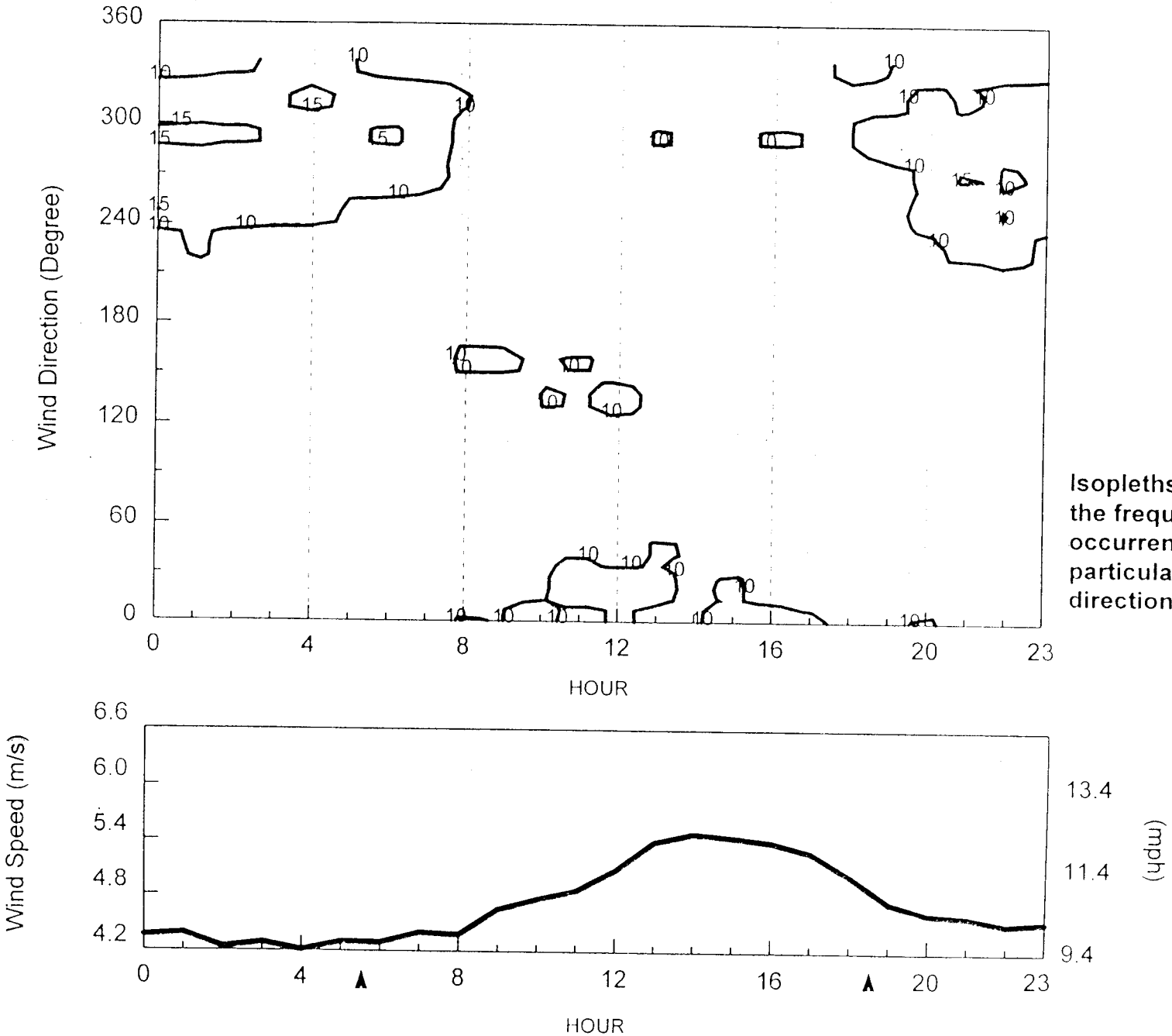
Triangles denote mean sunrise and sunset times.

FIGURE 2.16. January Hourly Wind-Direction Frequencies and Wind Speeds at 60 Meters.



Isopleths denote the frequency of occurrence of a particular wind-direction in percent.

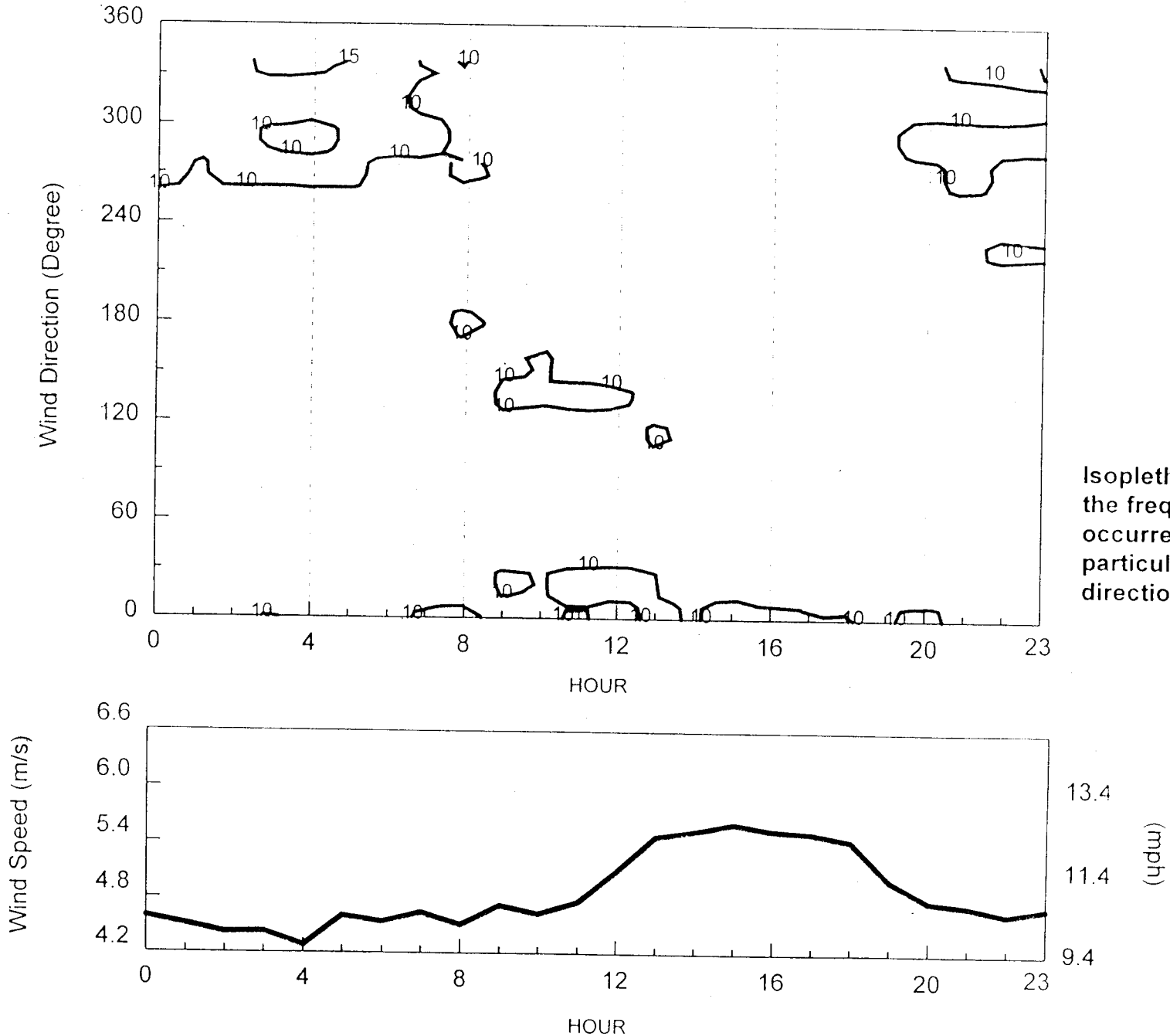
FIGURE 2.17. April Hourly Wind-Direction Frequencies and Wind Speeds at 10 Meters.



Isopleths denote the frequency of occurrence of a particular wind-direction in percent.

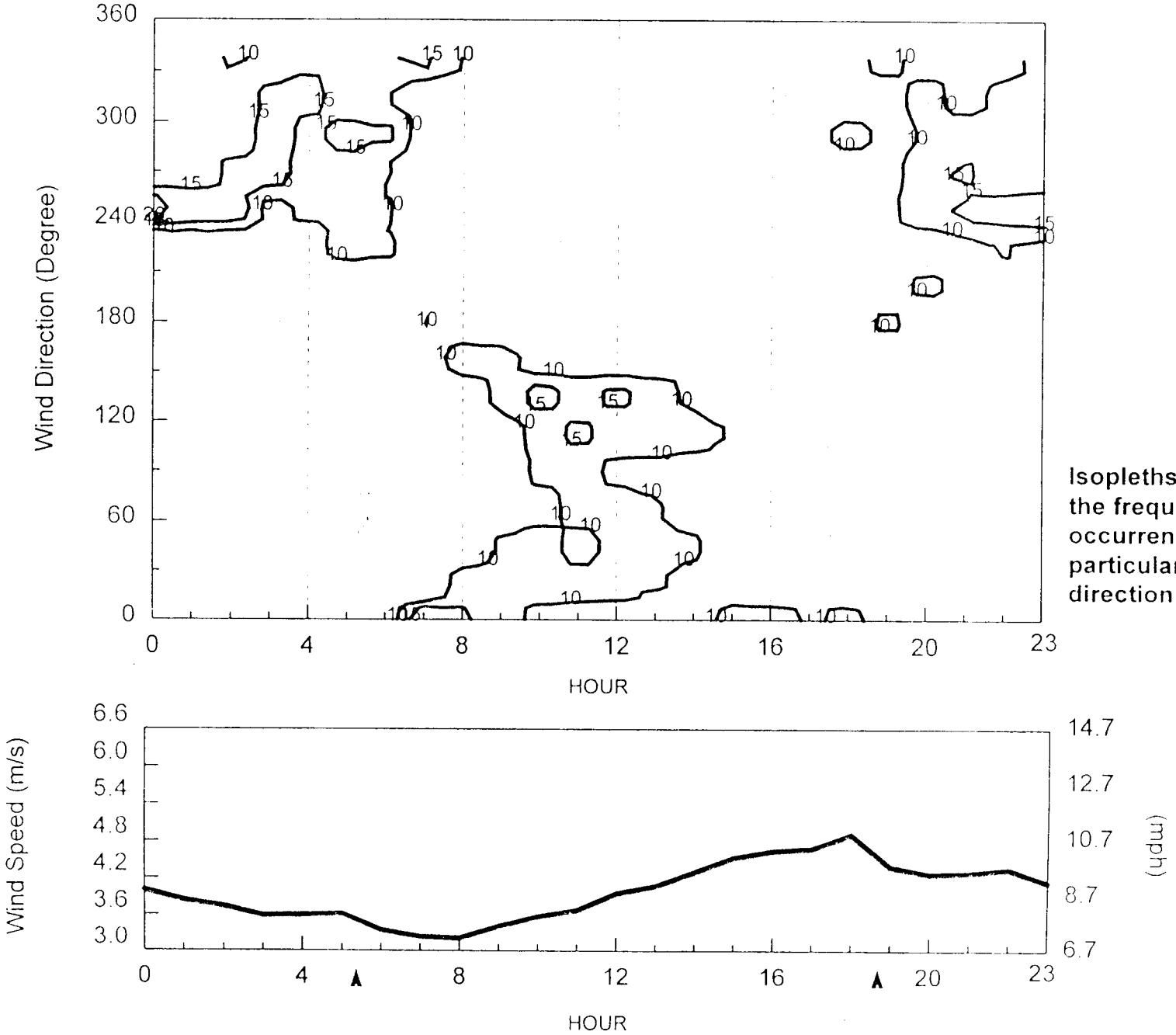
Triangles denote mean sunrise and sunset times.

FIGURE 2.18. April Hourly Wind-Direction Frequencies and Wind Speeds at 60 Meters.



Isopleths denote the frequency of occurrence of a particular wind-direction in percent.

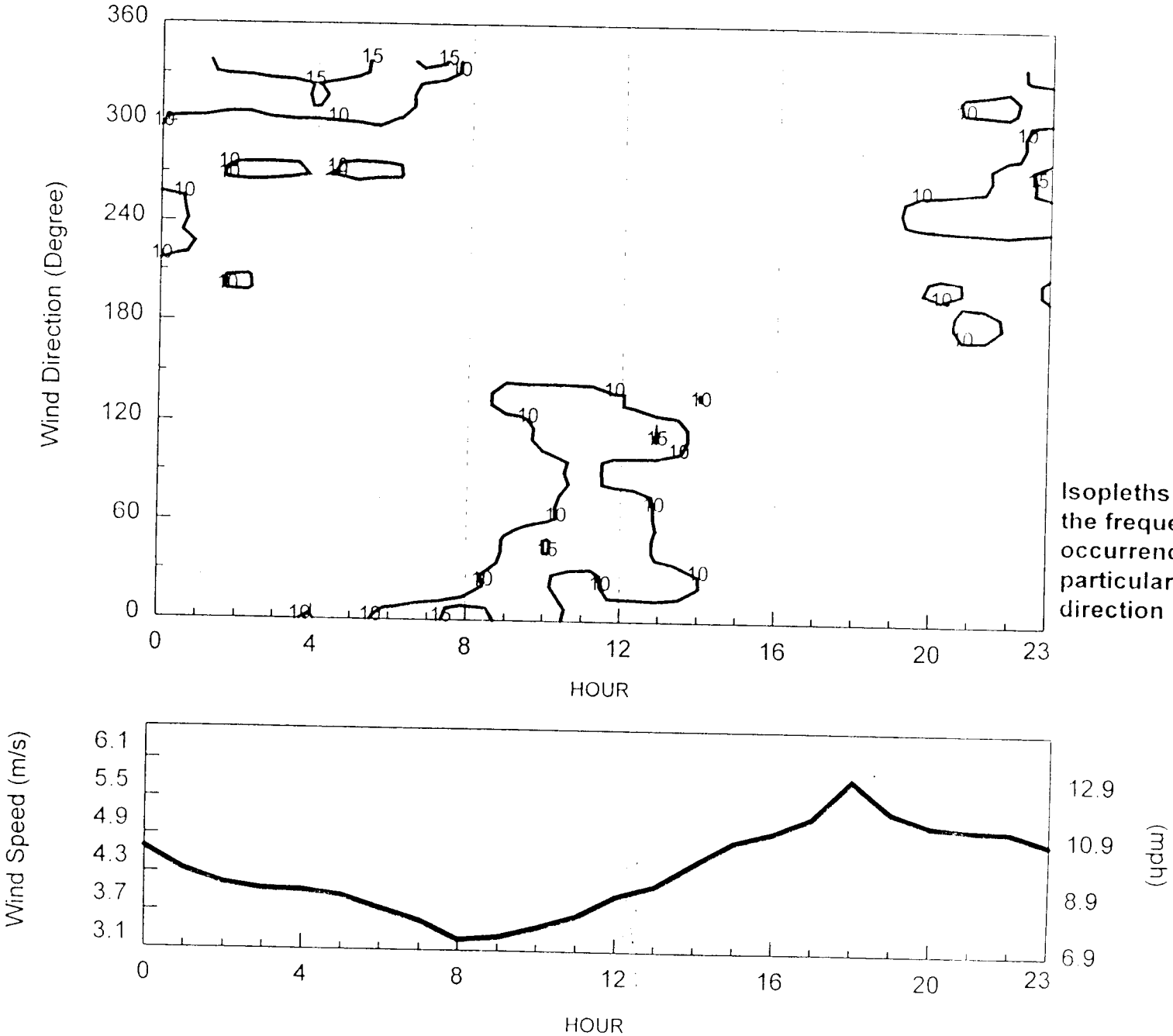
FIGURE 2.19. July Hourly Wind-Direction Frequencies and Wind Speeds at 10 Meters.



Isopleths denote the frequency of occurrence of a particular wind-direction in percent.

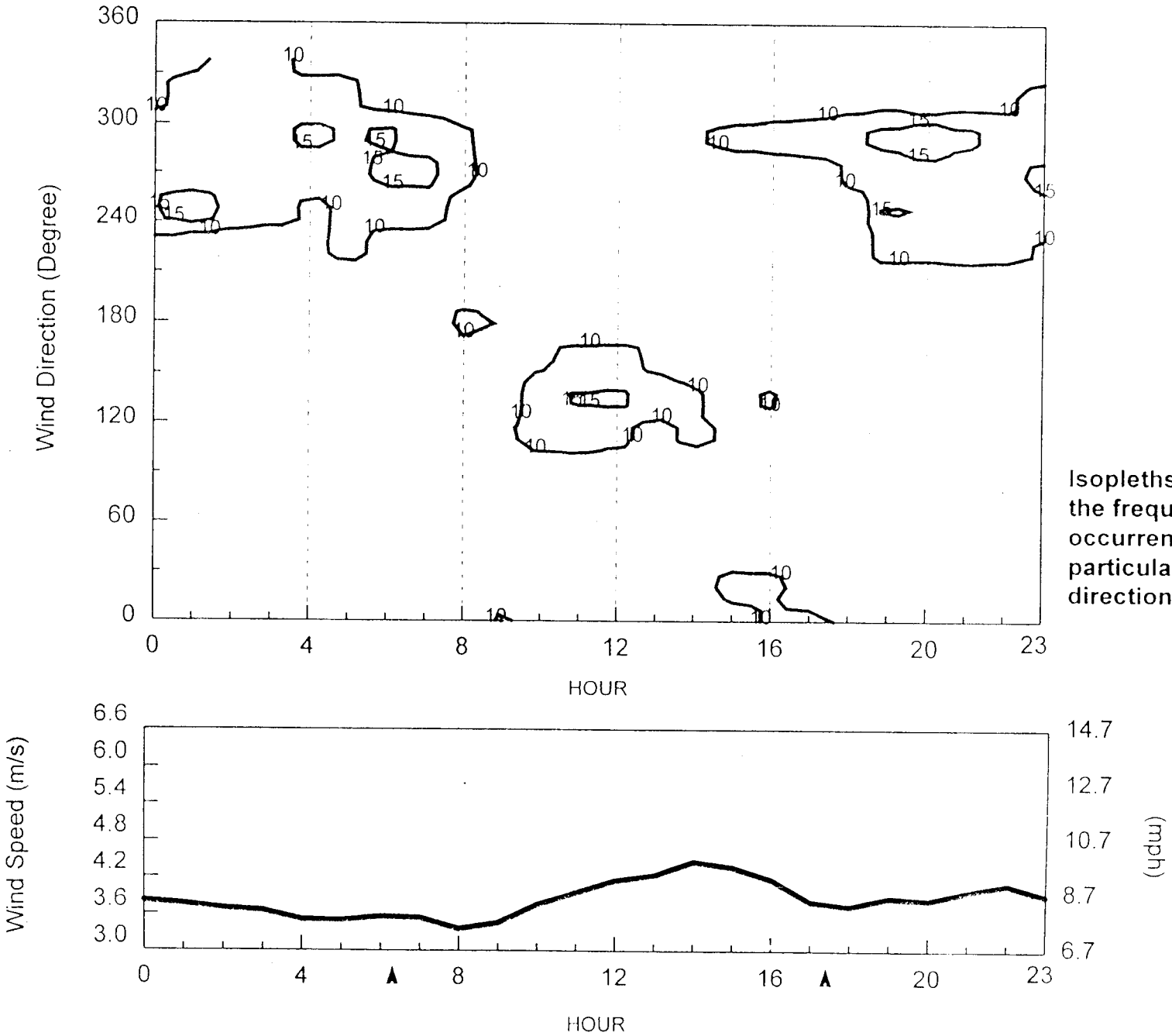
Triangles denote mean sunrise and sunset times.

FIGURE 2.20. July Hourly Wind-Direction Frequencies and Wind Speeds at 60 Meters.



Isopleths denote the frequency of occurrence of a particular wind-direction in percent.

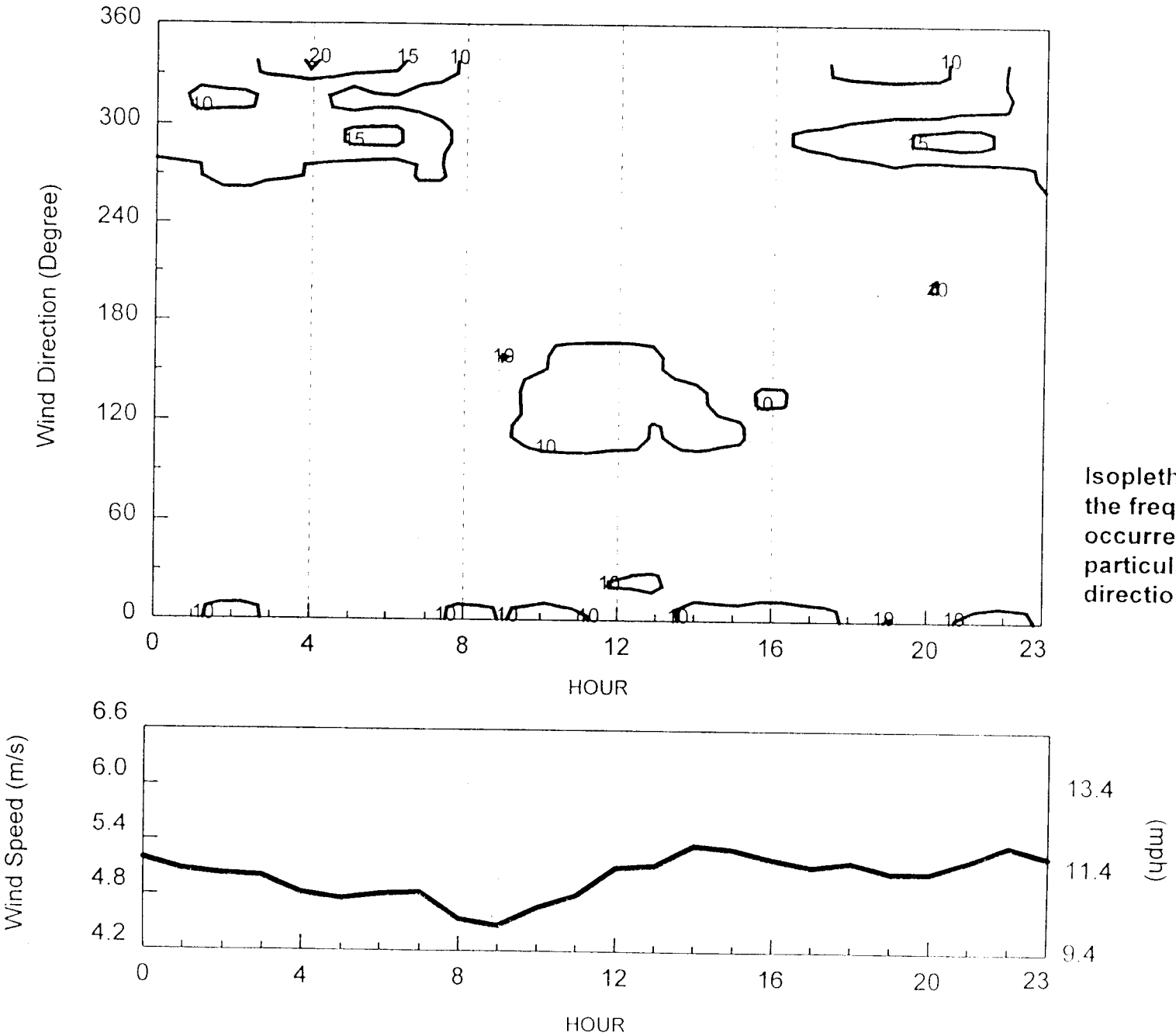
FIGURE 2.21. October Hourly Wind-Direction Frequencies and Wind Speeds at 10 Meters.



Isopleths denote the frequency of occurrence of a particular wind-direction in percent.

Triangles denote mean sunrise and sunset times.

FIGURE 2.22. October Hourly Wind-Direction Frequencies and Wind Speeds at 60 Meters.



Isopleths denote the frequency of occurrence of a particular wind-direction in percent.

2.5.3 Monthly Mean and Peak Winds

The monthly mean and peak wind speeds are summarized in Figure 2.23 and Table 2.29. The average monthly peak wind speeds for each of the 12 months were calculated from the corresponding monthly maximum wind speeds collected during 1953-1977 and 1984-1993. The average monthly wind speeds were calculated from all wind speed data collected during the entire periods (1964-1977 and 1984-1993) and segregated by month. Monthly wind speed data were not available before 1964. Although the 1953-1977 peak wind speeds were defined as peak wind gusts, these data were treated as peak wind speeds in the averaging calculations (see Section 1.3.2).

FIGURE 2.23. Monthly Mean and Average Peak Wind Speeds

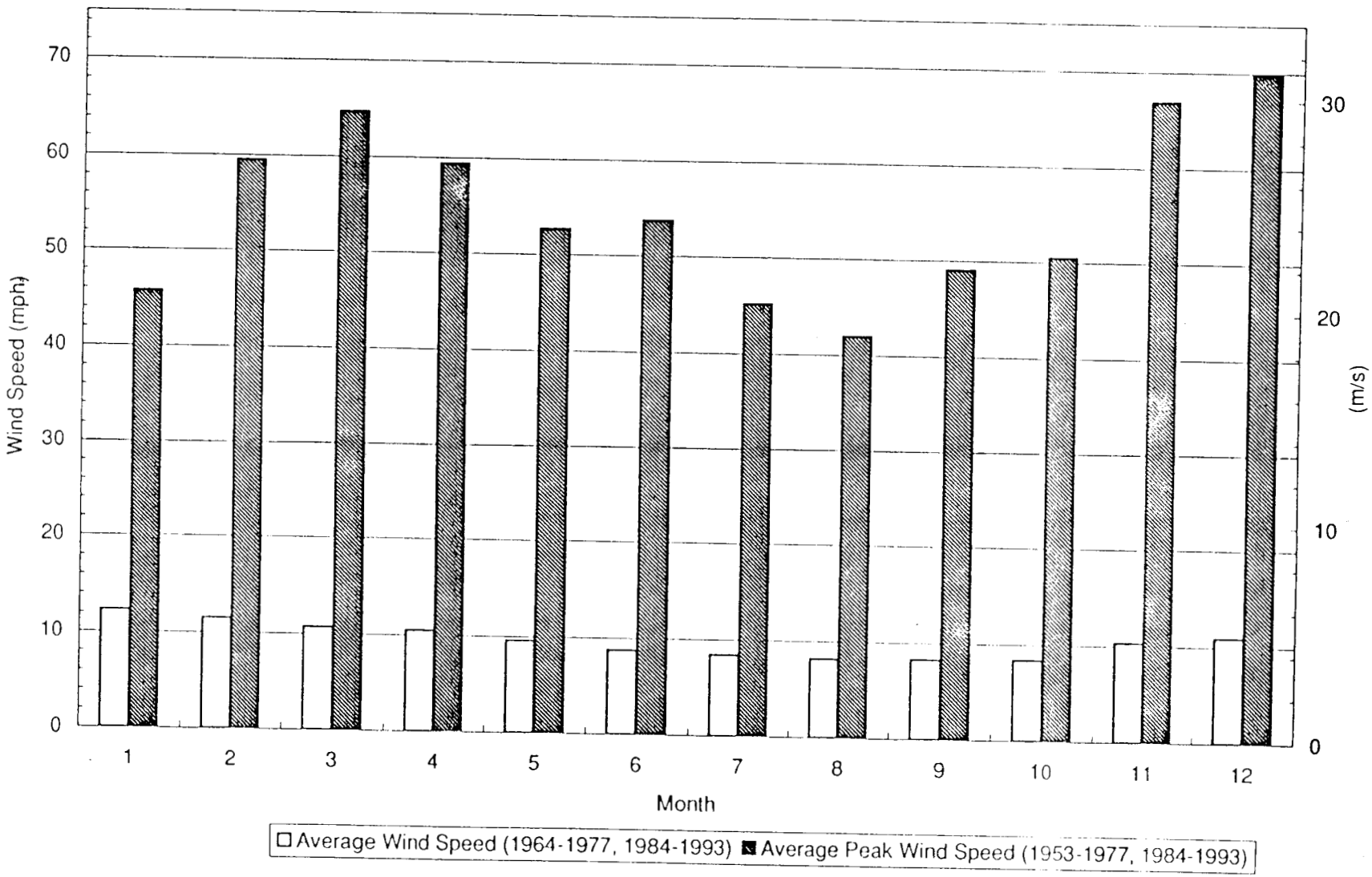


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TABLE 2.29. Monthly Mean and Average Peak Wind Speeds.

	1964-1977, 1984-1993	1953-1977, 1984-1993
Month	Average Wind Speed (mph)	Average Peak Wind Speed (mph)
	Average Wind Speed	Peak Wind Speed
1	12.3	45.7
2	11.5	59.6
3	10.7	64.7
4	10.5	59.4
5	9.6	52.7
6	8.7	53.7
7	8.4	45.2
8	8.1	42.0
9	8.2	49.0
10	8.4	50.5
11	10.3	67.0
12	10.9	69.9

2.6 BAROMETRIC PRESSURE AND DENSITY

2.6.1 Means and Extremes and Pressure Adjustment

Figure 2.24 presents the monthly mean and upper and lower 10% atmospheric pressure. Table 2.30 presents the monthly atmospheric pressure mean, extremes and adjusted sea level pressures in millibars and inches of mercury. The analyses were based on the 1964-1977 and 1984-1993 data sets. Barometric pressure data were not available before 1964.

The sea level adjustment was calculated using the ratio of the average annual site pressure and the average annual adjusted sea level pressure for Denver-Stapleton.

FIGURE 2.24. Monthly Mean Atmospheric Pressure at SITE

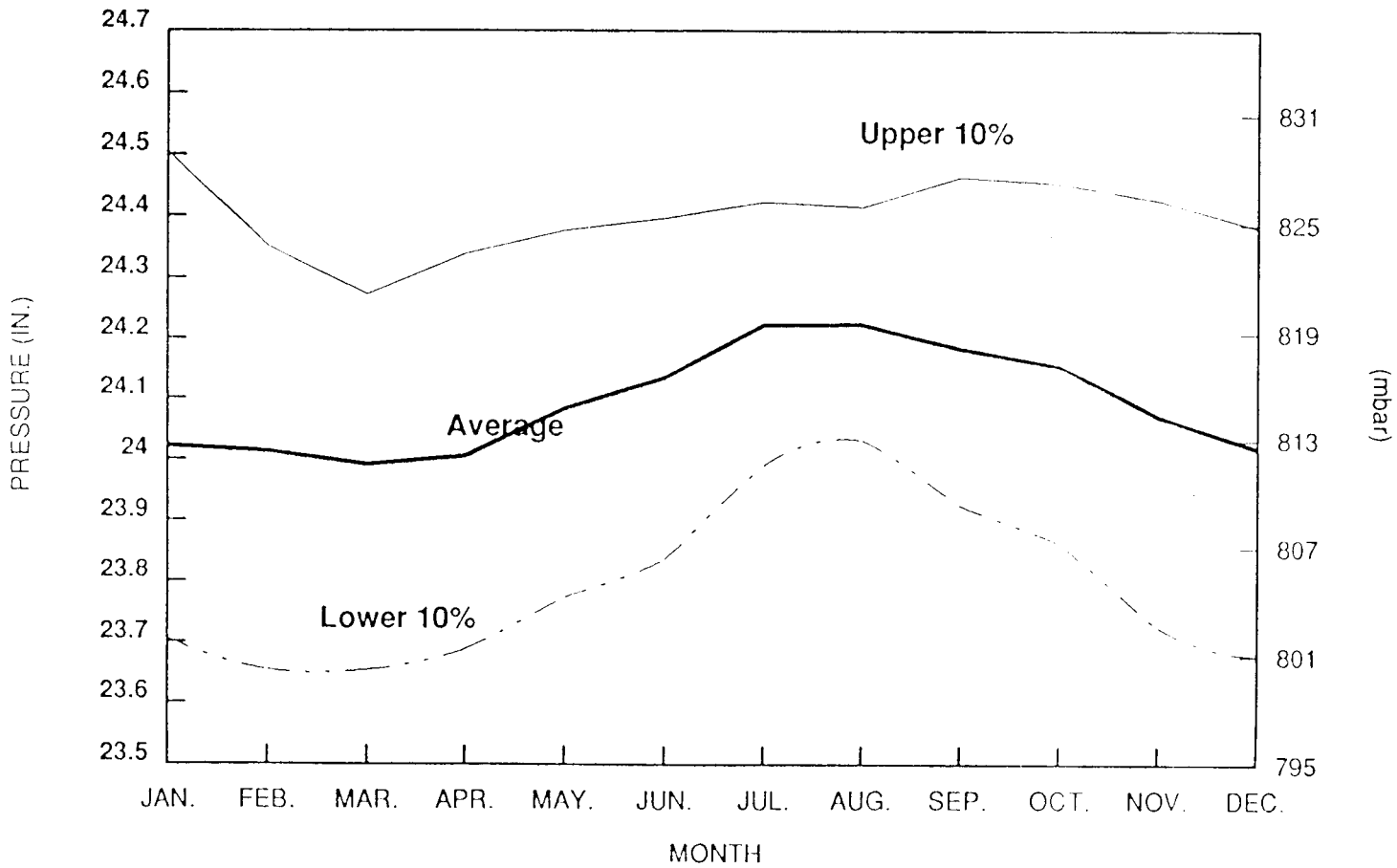


TABLE 2.30. Monthly Atmospheric Pressure, Means, and Extremes (1964-1977, 1984-1993).

Month	Mean	Monthly std dev	Extremes high	Extremes low	Adjusted to Sea Level Mean	Adjusted to Sea Level Extremes high	Adjusted to Sea Level Extremes low
Atmospheric Pressure (mbar Hg)							
1	813.5	6.9	840.2	791.8	1011.3	1044.5	984.3
2	813.2	7.2	832.4	718.6	1010.9	1034.8	893.3
3	812.5	6.1	836.5	794.3	1010.0	1039.8	987.4
4	812.9	6.1	830.0	786.0	1010.6	1031.8	977.1
5	815.6	6.0	837.5	781.3	1013.8	1041.1	971.2
6	817.3	6.3	840.9	717.6	1016.0	1045.3	892.1
7	820.3	4.3	830.7	802.6	1019.7	1032.7	997.7
8	820.3	3.7	829.7	809.6	1019.7	1031.4	1006.4
9	819.0	5.0	831.0	789.7	1018.1	1033.0	981.6
10	818.0	5.7	831.7	800.1	1016.8	1033.9	994.6
11	815.1	6.7	834.1	796.3	1013.3	1036.9	989.9
12	813.3	6.8	840.5	791.1	1011.1	1044.9	983.4
Annual	815.9	5.9	834.6	781.6	1014.3	1037.5	971.6

Month	Mean	Monthly std dev	Extremes high	Extremes low	Adjusted to Sea Level Mean	Adjusted to Sea Level Extremes high	Adjusted to Sea Level Extremes low
Atmospheric Pressure (in. Hg)							
1	24.02	0.20	24.81	23.38	29.86	30.84	29.06
2	24.01	0.21	24.58	21.22	29.85	30.56	26.38
3	23.99	0.18	24.70	23.45	29.82	30.70	29.16
4	24.01	0.18	24.51	23.21	29.84	30.47	28.85
5	24.08	0.18	24.73	23.07	29.94	30.74	28.68
6	24.13	0.18	24.83	21.19	30.00	30.87	26.34
7	24.22	0.13	24.53	23.70	30.11	30.49	29.46
8	24.22	0.11	24.50	23.91	30.11	30.46	29.72
9	24.18	0.15	24.54	23.32	30.06	30.50	28.99
10	24.15	0.17	24.56	23.63	30.02	30.53	29.37
11	24.07	0.20	24.63	23.52	29.92	30.62	29.23
12	24.02	0.20	24.82	23.36	29.86	30.85	29.04
Annual	24.09	0.17	24.64	23.08	29.95	30.64	28.69

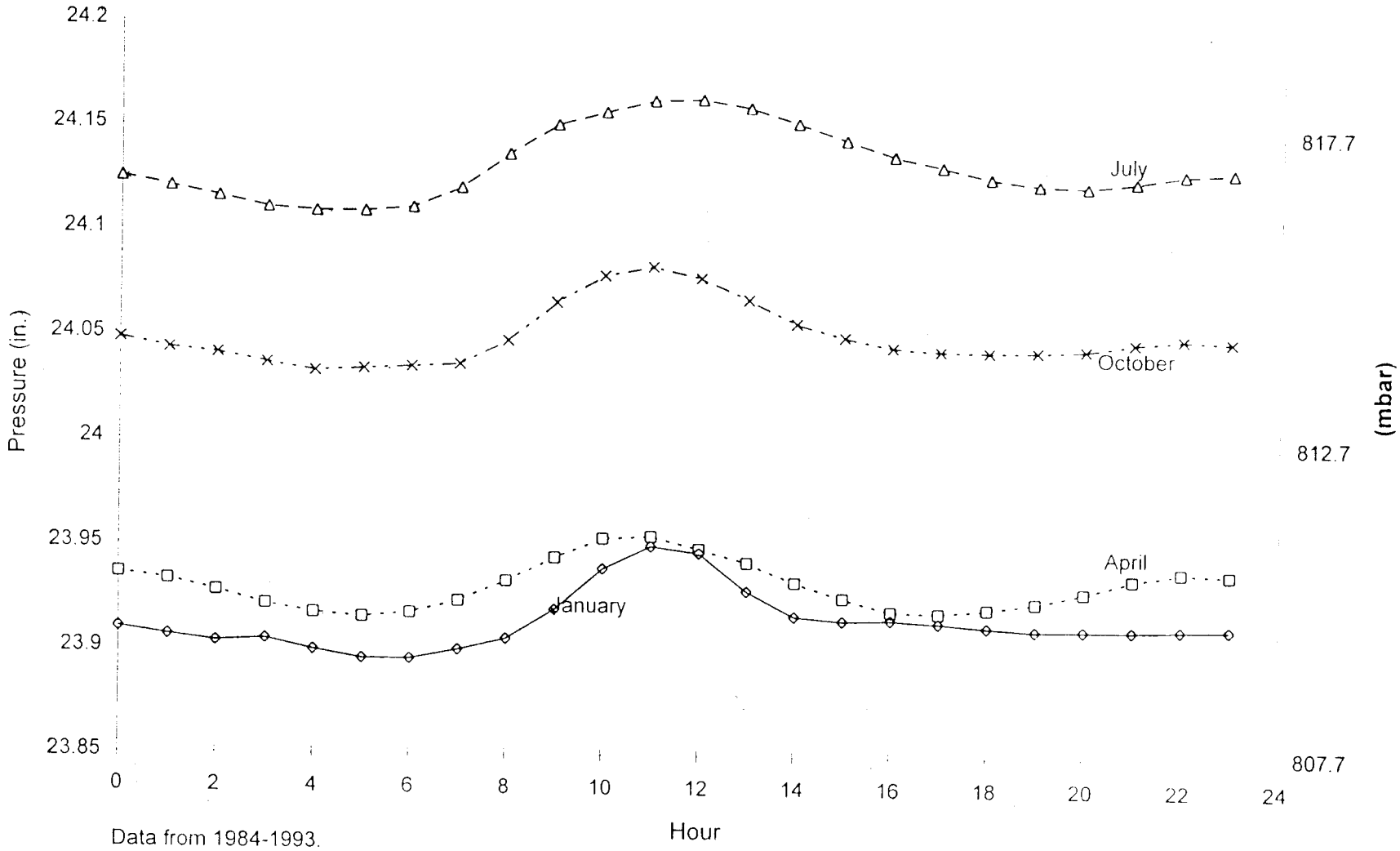
Conversions:

1 standard atmosphere (std atm) = 29.92 in. of Hg
=760 mm of Hg
=76.0 cm of Hg
=1.0133 bar
=1013.3 mbar
=101.33 kPa
=101325 Pa
=14.69 lb/in.^2

2.6.2 Hourly Seasonal Pressure

Figure 2.25 was based on the 1984-1993 data set only. Hourly barometric pressure data were not available before 1984. The data presented in this figure are a combination of diurnal variation and synoptic variation.

FIGURE 2.25. Hourly Mean Atmospheric Pressure at SITE During January, April, July, and October (1984-1993).



Data from 1984-1993.

SITE2.xls chart cc-1/30/95

2.6.3 Atmospheric Density

Table 2.31 was based on the 1964-1977 and 1984-1993 data sets only. Barometric pressure data were not available before 1964. Atmospheric density is calculated using the following equations:

$$\rho = \frac{P}{TvR}$$

Where:

ρ = Density (kg/m^3)
P = Atmospheric pressure (kPa)
Tv $\cong$ T (1 + 0.61 w)
R = Gas constant for dry air (287.05 $jkg^{-1}k^{-1}$)

WHERE:

Tv = Virtual temperature (°k)
T = Actual temperature (°k)
w = Mixing ratio (grams of water/gram of air)

TABLE 2.31. Monthly Mean Atmospheric Density at SITE (1964-1977, 1984-1993).

Month	Atmospheric Density (Kg/m3)	Month	Atmospheric Density (kg/m3)
January	0.93	July	0.83
February	0.92	August	0.84
March	0.91	September	0.86
April	0.89	October	0.88
May	0.87	November	0.91
June	0.84	December	0.93
		Annual	0.88

2.7 INSOLATION

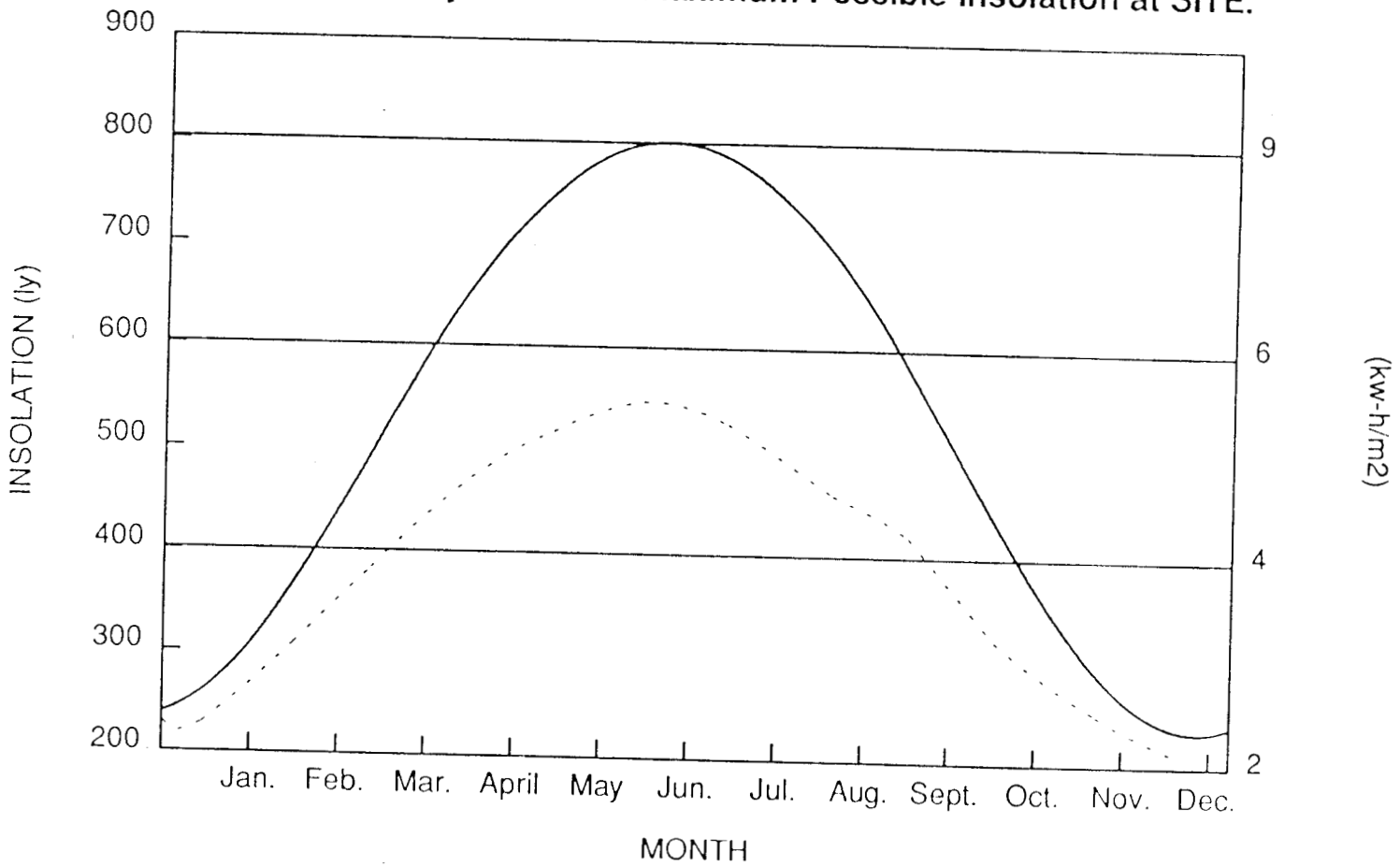
2.7.1 Mean and Maximum Insolation

Figures 2.26 through 2.30 and Table 2.32 were based on the 1984-1993 data set only and does not include Denver data for comparison. Insolation data were not available before 1984.

The maximum insolation curves were calculated using an approximation to the equations used to generate planet position tables in The Astronomical Almanac (U.S. Government, 1992). These equations calculate the azimuth and elevation of the sun in relation to a specific location and time on the earth. A correction was added to compensate for optical refraction caused by the atmosphere.

The monthly and daily mean insolation values are lower than expected, based on the percent of possible insolation calculations presented in Table 2.32. Data quality is the underlying reason for this result since the averages are based on incomplete data sets and data of questionable quality.

FIGURE 2.26. Daily Mean and Maximum Possible Insolation at SITE.



Maximum possible insolation at SITE

Mean insolation at SITE

FIGURE 2.27. Hourly Mean and Maximum Possible Insolation at SITE.

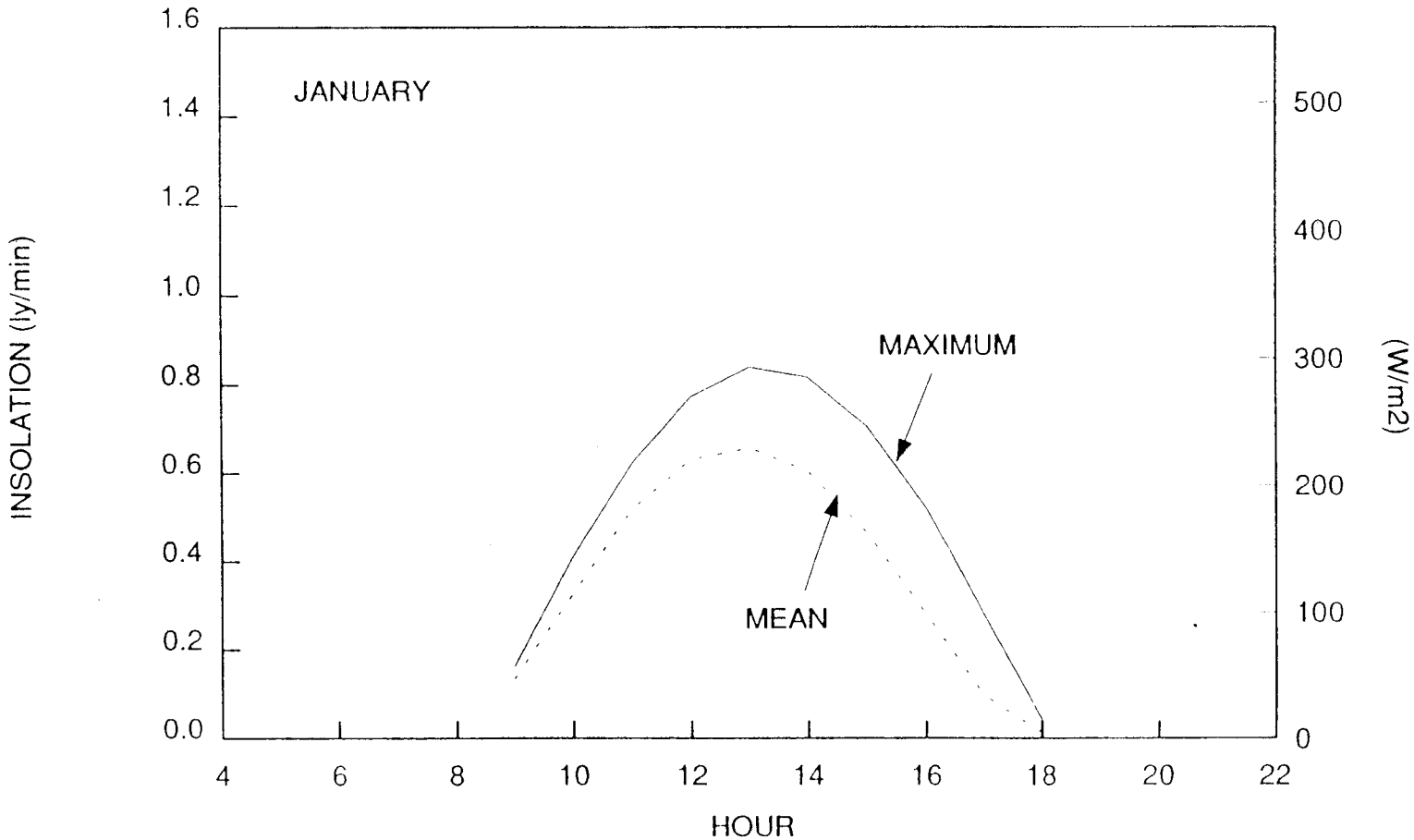


FIGURE 2.28. Hourly Mean and Maximum Possible Insolation at SITE.

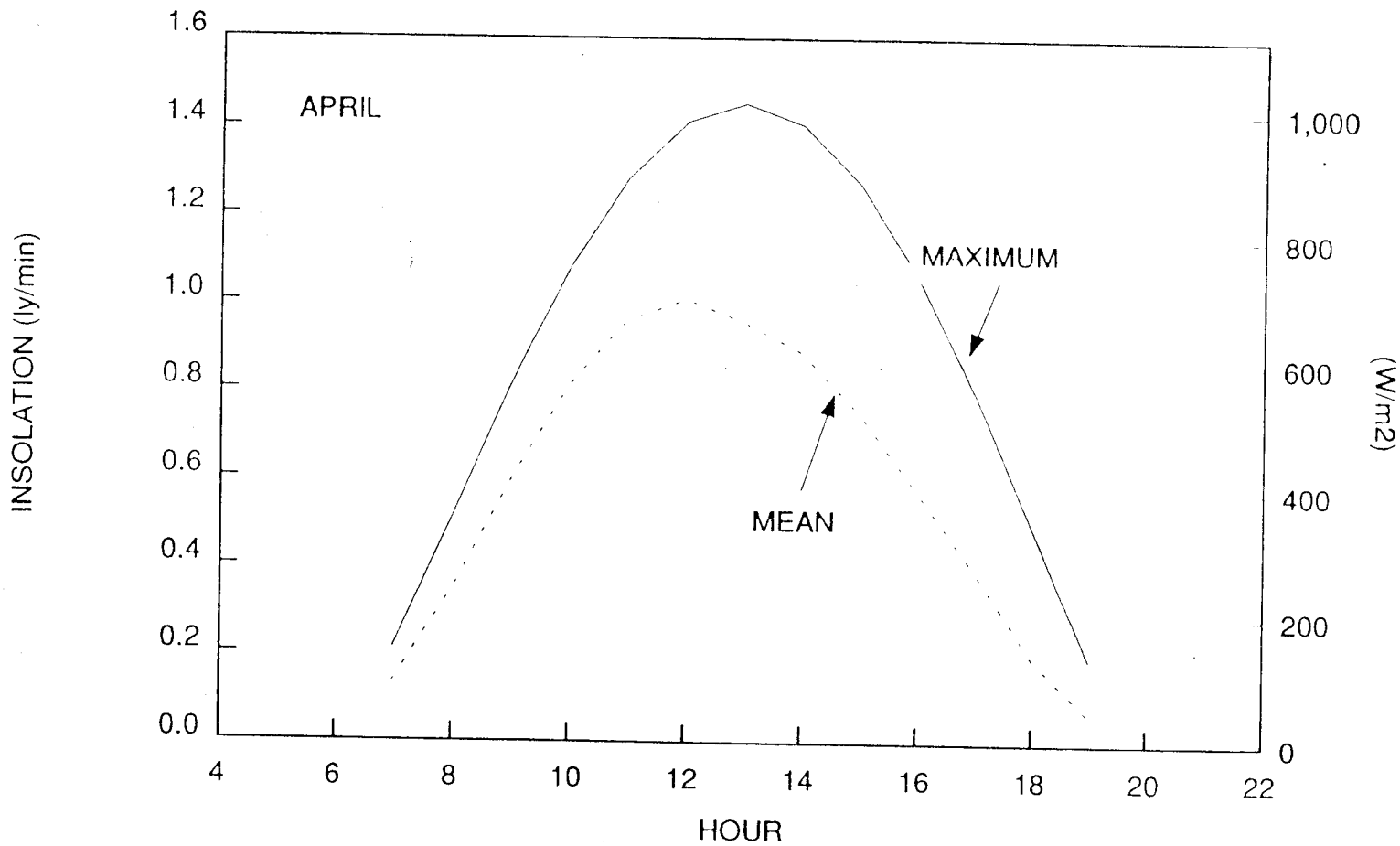


FIGURE 2.29. Hourly Mean and Maximum Possible Insolation at SITE.

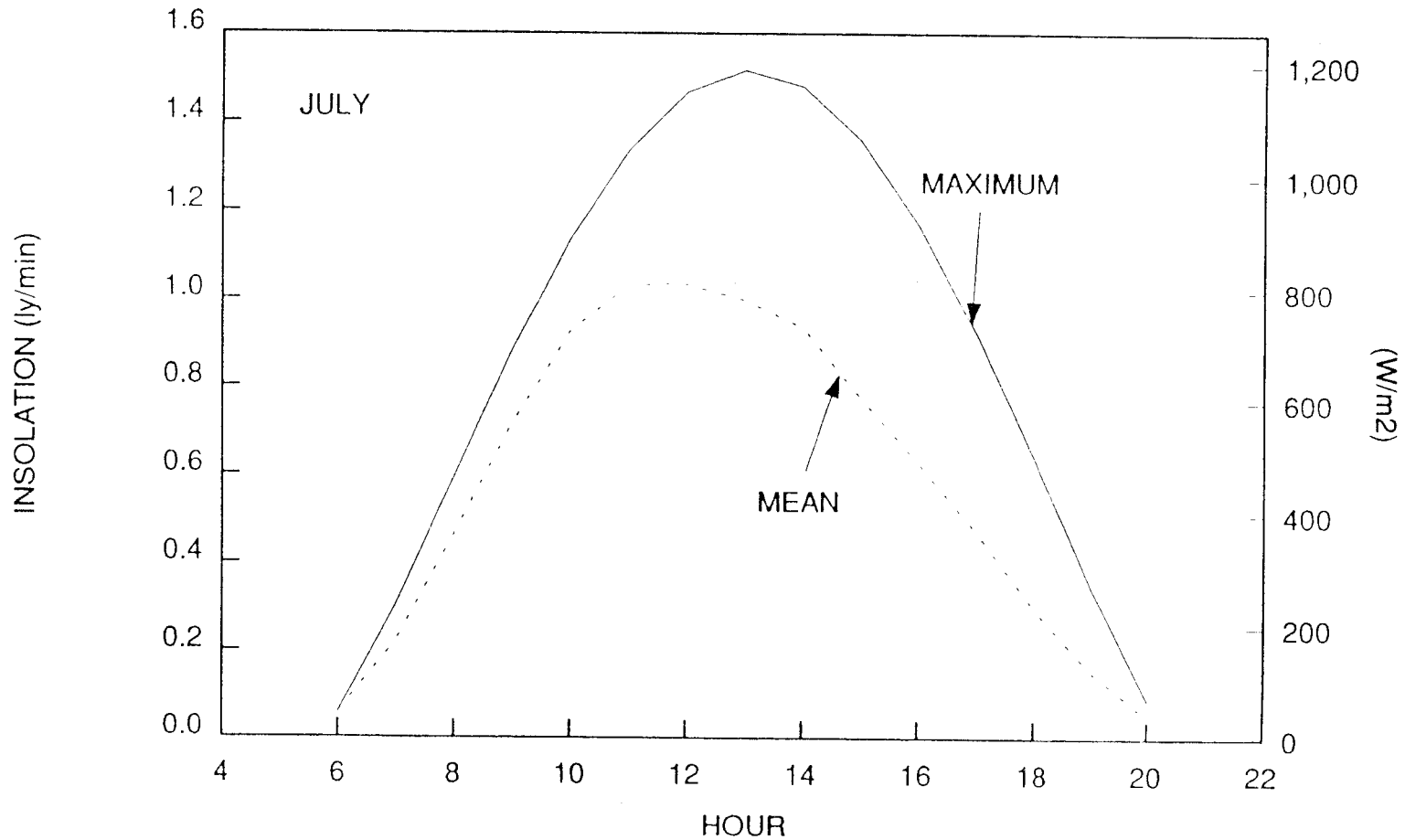


FIGURE 2.30. Hourly Mean and Maximum Possible Insolation at SITE.

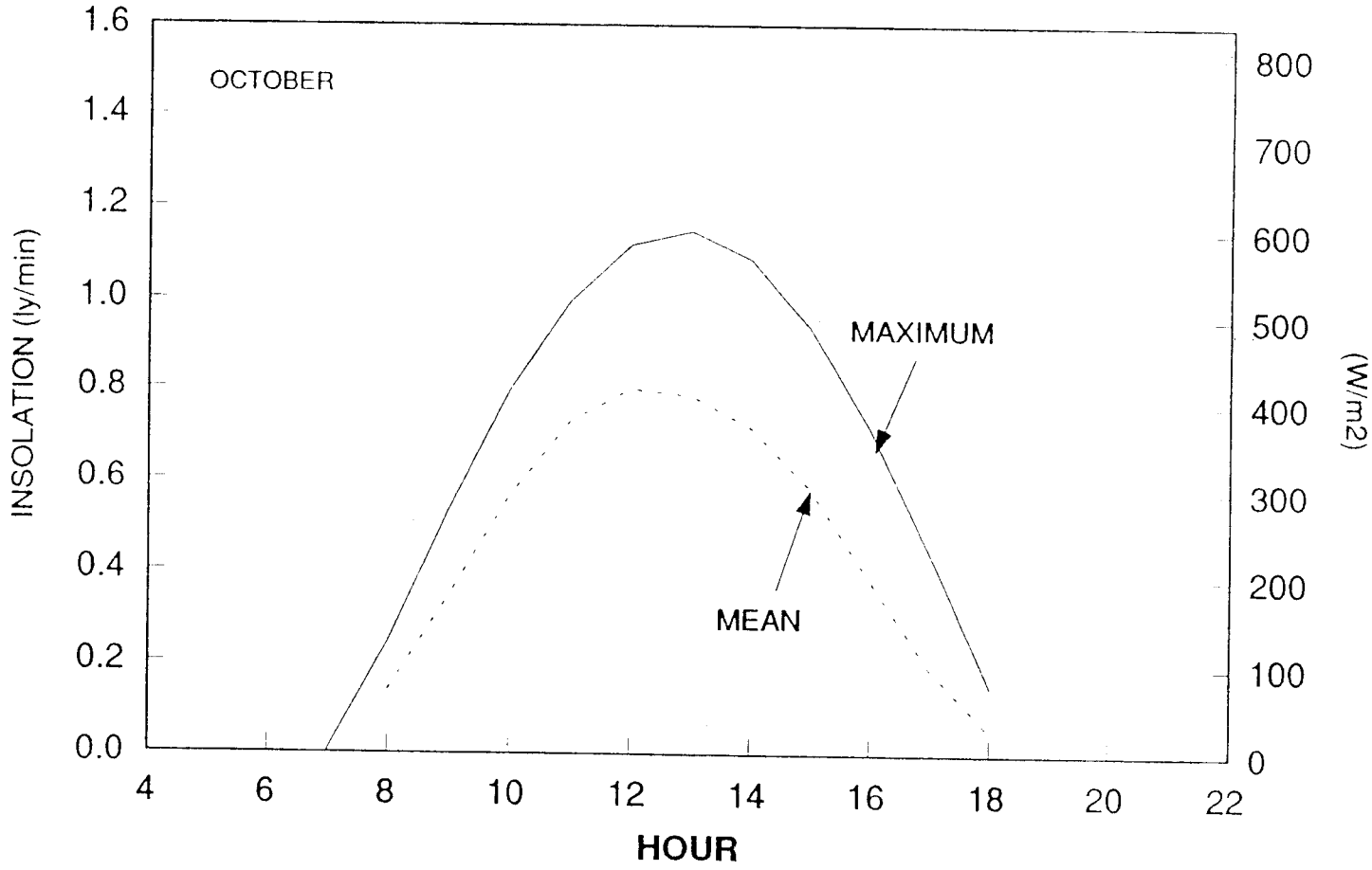


TABLE 2.32. Monthly and Daily Insolation Statistics at SITE (1984-1993).

	Maximum Possible		SITE Actual		
	Daily	Monthly	Daily	Monthly	% Possible
Radiation (ly):					
January	269	8,327	229	7,087	85.1
February	375	10,877	309	8,970	82.5
March	521	16,166	384	11,912	73.7
April	663	19,901	473	14,177	71.2
May	760	23,557	519	16,097	68.3
June	799	23,979	549	16,466	68.7
July	775	24,023	528	16,372	68.2
August	692	21,445	461	14,302	66.7
September	564	16,912	421	12,640	74.7
October	417	12,928	321	9,958	77.0
November	294	8,818	250	7,490	84.9
December	238	7,393	210	6,496	87.9
Annual	531	194,327	388	141,966	75.7

2.7.2 Sunrise, Sunset

The Site's sunrise and sunset times presented in Table 2.33 were calculated using an approximation to the equations used to generate planet position tables in The Astronomical Almanac (U.S. Government, 1992). These equations calculate the azimuth and elevation of the sun in relation to a specific location and time on the earth. A correction was added to compensate for optical refraction caused by the atmosphere.

TABLE 2.33. SITE Sunrise and Sunset Times.

	January		February		March		April		May		June		July	
Day	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set
1	7:30	16:42	7:12	17:12	6:36	17:48	5:48	18:18	5:06	18:48	4:42	19:18	4:42	19:30
2	7:30	16:42	7:12	17:12	6:36	17:48	5:48	18:18	5:06	18:48	4:36	19:18	4:42	19:30
3	7:30	16:42	7:12	17:18	6:36	17:48	5:48	18:24	5:06	18:54	4:36	19:18	4:42	19:30
4	7:30	16:42	7:12	17:18	6:36	17:54	5:42	18:24	5:00	18:54	4:36	19:18	4:42	19:30
5	7:30	16:42	7:12	17:18	6:30	17:54	5:42	18:24	5:00	18:54	4:36	19:18	4:42	19:30
6	7:30	16:42	7:12	17:18	6:30	17:54	5:42	18:24	5:00	18:54	4:36	19:24	4:42	19:30
7	7:30	16:48	7:06	17:18	6:30	17:54	5:42	18:24	5:00	18:54	4:36	19:24	4:42	19:30
8	7:30	16:48	7:06	17:24	6:30	17:54	5:36	18:24	5:00	18:54	4:36	19:24	4:42	19:24
9	7:30	16:48	7:06	17:24	6:24	17:54	5:36	18:30	4:54	19:00	4:36	19:24	4:48	19:24
10	7:30	16:48	7:06	17:24	6:24	18:00	5:36	18:30	4:54	19:00	4:36	19:24	4:48	19:24
11	7:30	16:48	7:06	17:24	6:24	18:00	5:36	18:30	4:54	19:00	4:36	19:24	4:48	19:24
12	7:24	16:48	7:06	17:30	6:24	18:00	5:30	18:30	4:54	19:00	4:36	19:24	4:48	19:24
13	7:24	16:54	7:00	17:30	6:18	18:00	5:30	18:30	4:54	19:00	4:36	19:24	4:48	19:24
14	7:24	16:54	7:00	17:30	6:18	18:00	5:30	18:30	4:54	19:00	4:36	19:24	4:48	19:24
15	7:24	16:54	7:00	17:30	6:18	18:00	5:30	18:36	4:48	19:06	4:36	19:24	4:48	19:24
16	7:24	16:54	7:00	17:30	6:18	18:06	5:24	18:36	4:48	19:06	4:36	19:24	4:48	19:24
17	7:24	16:54	7:00	17:36	6:12	18:06	5:24	18:36	4:48	19:06	4:36	19:24	4:54	19:24
18	7:24	17:00	6:54	17:36	6:12	18:06	5:24	18:36	4:48	19:06	4:36	19:24	4:54	19:24
19	7:24	17:00	6:54	17:36	6:12	18:06	5:24	18:36	4:48	19:06	4:36	19:30	4:54	19:24
20	7:24	17:00	6:54	17:36	6:06	18:06	5:18	18:36	4:48	19:06	4:36	19:30	4:54	19:18
21	7:24	17:00	6:54	17:36	6:06	18:12	5:18	18:42	4:48	19:06	4:36	19:30	4:54	19:18
22	7:24	17:00	6:48	17:36	6:06	18:12	5:18	18:42	4:42	19:12	4:36	19:30	4:54	19:18
23	7:24	17:00	6:48	17:42	6:06	18:12	5:18	18:42	4:42	19:12	4:36	19:30	4:54	19:18
24	7:24	17:06	6:48	17:42	6:00	18:12	5:12	18:42	4:42	19:12	4:36	19:30	5:00	19:18
25	7:18	17:06	6:48	17:42	6:00	18:12	5:12	18:42	4:42	19:12	4:36	19:30	5:00	19:18
26	7:18	17:06	6:42	17:42	6:00	18:12	5:12	18:42	4:42	19:12	4:36	19:30	5:00	19:18
27	7:18	17:06	6:42	17:42	6:00	18:18	5:12	18:48	4:42	19:12	4:42	19:30	5:00	19:18
28	7:18	17:06	6:42	17:48	5:54	18:18	5:12	18:48	4:42	19:12	4:42	19:30	5:00	19:12
29	7:18	17:12	6:42	17:48	5:54	18:18	5:06	18:48	4:42	19:18	4:42	19:30	5:00	19:12
30	7:18	17:12	---	---	5:54	18:18	5:06	18:48	4:42	19:18	4:42	19:30	5:00	19:12
31	7:18	17:12	---	---	5:54	18:18	---	---	4:42	19:18	---	---	5:06	19:12

TABLE 2.33. (Continued).

August		September		October		November		December	
Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set
5:06	19:12	5:30	18:30	6:00	17:42	6:36	16:54	7:06	16:30
5:06	19:12	5:36	18:24	6:00	17:36	6:36	16:54	7:12	16:30
5:06	19:06	5:36	18:24	6:00	17:36	6:36	16:54	7:12	16:30
5:06	19:06	5:36	18:24	6:06	17:36	6:36	16:54	7:12	16:30
5:06	19:06	5:36	18:24	6:06	17:30	6:42	16:48	7:12	16:30
5:06	19:06	5:36	18:18	6:06	17:30	6:42	16:48	7:12	16:30
5:12	19:06	5:36	18:18	6:06	17:30	6:42	16:48	7:12	16:30
5:12	19:00	5:42	18:18	6:06	17:30	6:42	16:48	7:18	16:30
5:12	19:00	5:42	18:18	6:06	17:24	6:42	16:48	7:18	16:30
5:12	19:00	5:42	18:12	6:12	17:24	6:48	16:48	7:18	16:30
5:12	19:00	5:42	18:12	6:12	17:24	6:48	16:42	7:18	16:30
5:12	19:00	5:42	18:12	6:12	17:24	6:48	16:42	7:18	16:30
5:18	18:54	5:42	18:06	6:12	17:18	6:48	16:42	7:18	16:30
5:18	18:54	5:42	18:06	6:12	17:18	6:48	16:42	7:18	16:30
5:18	18:54	5:48	18:06	6:12	17:18	6:54	16:42	7:24	16:30
5:18	18:54	5:48	18:06	6:18	17:18	6:54	16:42	7:24	16:30
5:18	18:48	5:48	18:00	6:18	17:12	6:54	16:42	7:24	16:36
5:18	18:48	5:48	18:00	6:18	17:12	6:54	16:36	7:24	16:36
5:18	18:48	5:48	18:00	6:18	17:12	6:54	16:36	7:24	16:36
5:24	18:48	5:48	18:00	6:18	17:12	6:54	16:36	7:24	16:36
5:24	18:48	5:48	17:54	6:24	17:06	7:00	16:36	7:24	16:36
5:24	18:42	5:54	17:54	6:24	17:06	7:00	16:36	7:24	16:36
5:24	18:42	5:54	17:54	6:24	17:06	7:00	16:36	7:24	16:36
5:24	18:42	5:54	17:48	6:24	17:06	7:00	16:36	7:24	16:36
5:24	18:42	5:54	17:48	6:24	17:06	7:00	16:36	7:24	16:36
5:30	18:36	5:54	17:48	6:30	17:00	7:06	16:36	7:24	16:36
5:30	18:36	5:54	17:48	6:30	17:00	7:06	16:36	7:24	16:36
5:30	18:36	6:00	17:42	6:30	17:00	7:06	16:36	7:30	16:36
5:30	18:36	6:00	17:42	6:30	17:00	7:06	16:36	7:30	16:42
5:30	18:30	6:00	17:42	6:30	17:00	7:06	16:30	7:30	16:42
5:30	18:30	---	---	6:36	16:54	---	---	7:30	16:42

2.8 EXTREMES

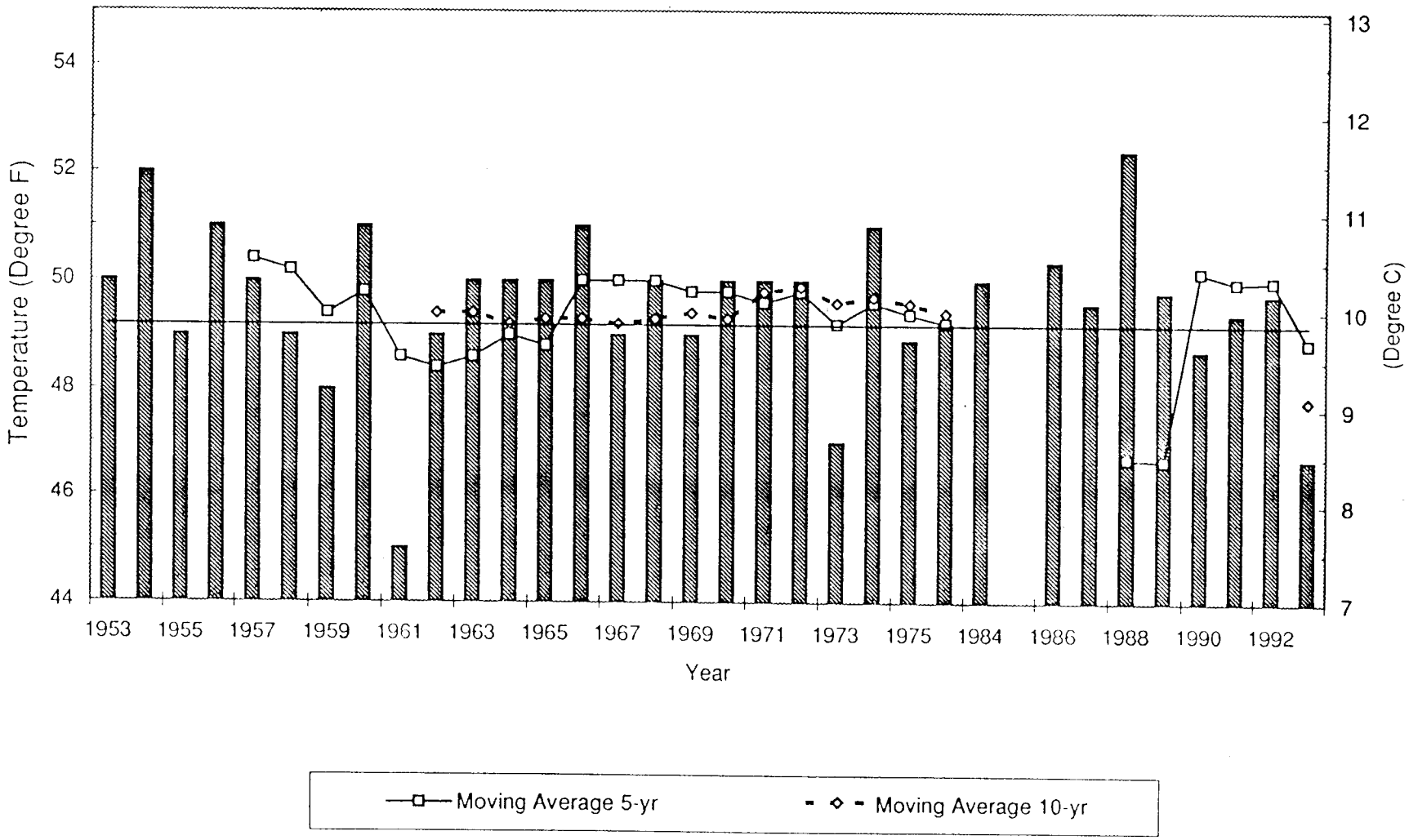
2.8.1 Annual Mean Temperatures and Precipitation

Figure 2.31 presents the annual mean temperatures and five- and 10-year back-calculated moving averages. The annual mean temperatures for 1953-1976 were taken from the paper annual summaries available for those years. The annual mean temperatures for 1984-1993 were calculated from the available 15-minute data. Average temperatures were not impacted by the local effects of the various site locations.

Figure 2.32 presents the annual precipitation amounts and five- and 10-year back-calculated moving averages. The annual precipitation totals for 1953-1976 were taken from the paper annual summaries available for those years. The annual precipitation totals for years 1984-1993 were calculated from the available 15-minute data. The 1984-1986 data were excluded along with the moving averages that would have included these data.

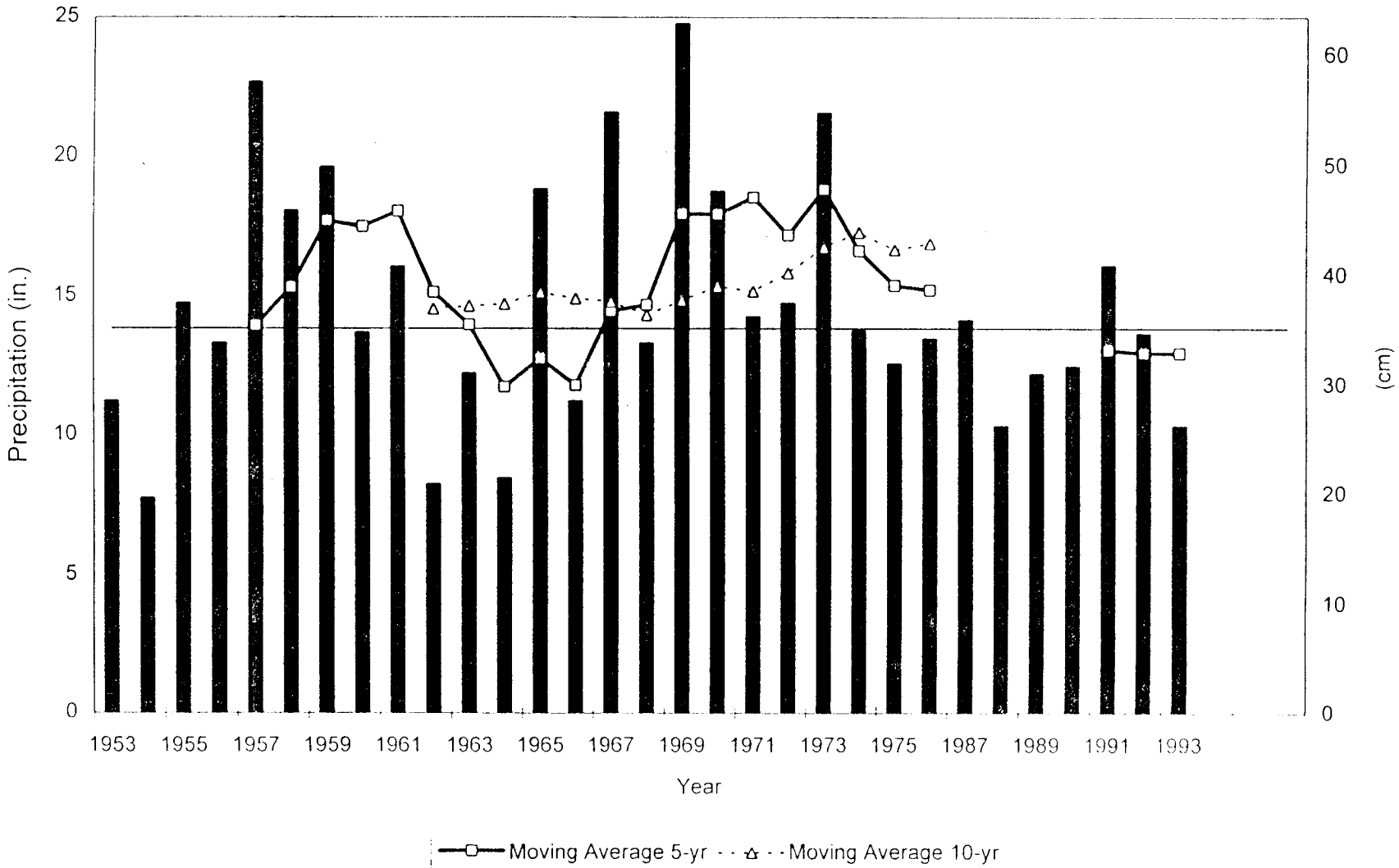
Table 2.34 summarizes the annual mean temperatures and annual precipitation data.

FIGURE 2.31. SITE Historical Annual Mean Temperatures (1953-1977, 1984-1993).



SITE3.XLS-Chart-kk 1-25.1.95

FIGURE 2.32. SITE Historical Annual Precipitation (1953-1977, 1987-1993).



SITE3315.chart1112-3/27/95

TABLE 2.34. SITE Annual Mean Temperatures and Precipitation (1953-1976, 1984-1993).

YEAR	Annual Mean Temperature (Degree F)	Annual Precipitation (in.)
1953	50.0	11.3
1954	52.0	7.8
1955	49.0	14.8
1956	51.0	13.4
1957	50.0	22.7
1958	49.0	18.1
1959	48.0	19.7
1960	51.0	13.7
1961	45.0	16.1
1962	49.0	8.3
1963	50.0	12.3
1964	50.0	8.5
1965	50.0	18.9
1966	51.0	11.3
1967	49.0	21.6
1968	50.0	13.4
1969	49.0	24.8
1970	50.0	18.8
1971	50.0	14.3
1972	50.0	14.8
1973	47.0	21.6
1974	51.0	13.8
1975	48.9	12.6
1976	49.2	13.5
1984	50.0	6.8
1985	31.1	0.5
1986	50.4	9.4
1987	49.6	14.2
1988	52.4	10.3
1989	49.8	12.2
1990	48.7	12.5
1991	49.4	16.1
1992	49.7	13.7
1993	46.7	10.3

* Partial years are 1984-1986.

2.8.2 Precipitation Return Periods

Figure 2.33 presents the annual precipitation amounts for each year (1953-1977 and 1984-1993) as a function of its location on the annual precipitation frequency distribution. The return period scale interprets the frequency distribution scale into the number of years that statistically would elapse until the recurrence of a particular annual precipitation amount.

Figures 2.34, 2.35 and 2.36 present the same type of information as Figure 2.33 except they present monthly, daily, 12-hourly, 1-hourly and 15-minute extreme precipitation amounts plotted as a function of their location on their respective frequency distribution scales. The return period scales again interpret the frequency distribution scales into the number of years that statistically would elapse until the recurrence of a particular monthly, daily, 12-hour, 1-hour or 15-minute precipitation amount.

Figures 2.33 and 2.34 were based on the 1953-1977 and 1984-1993 data sets. Figure 2.35 was based on the 1964-1977 and 1984-1993 data sets only. Figure 2.36 was based on the 1984-1993 data set only. Daily precipitation data were not available before 1964. Twelve-hour, 1-hour and 15-minute data were not available before 1984. Years 1984-1986 were eliminated from the analyses (see Section 1.3.2). Table 2.35 summarizes the return periods for each of the data averaging periods.

FIGURE 2.33. Annual Extreme Precipitation for SITE (1953-1977, 1987-1993).

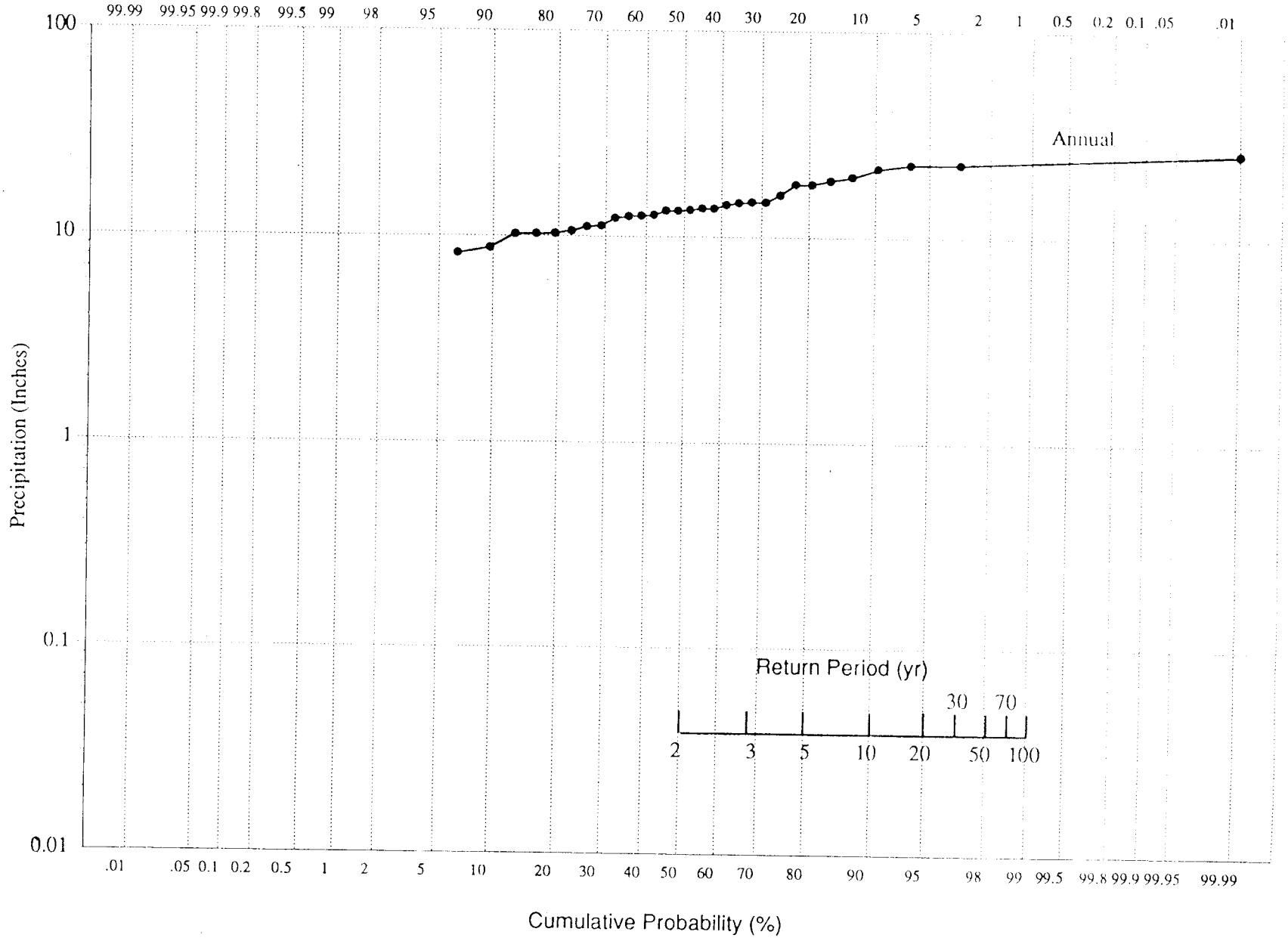


FIGURE 2.34. Monthly Extreme Precipitation for SITE (1953-1977, 1987-1993).

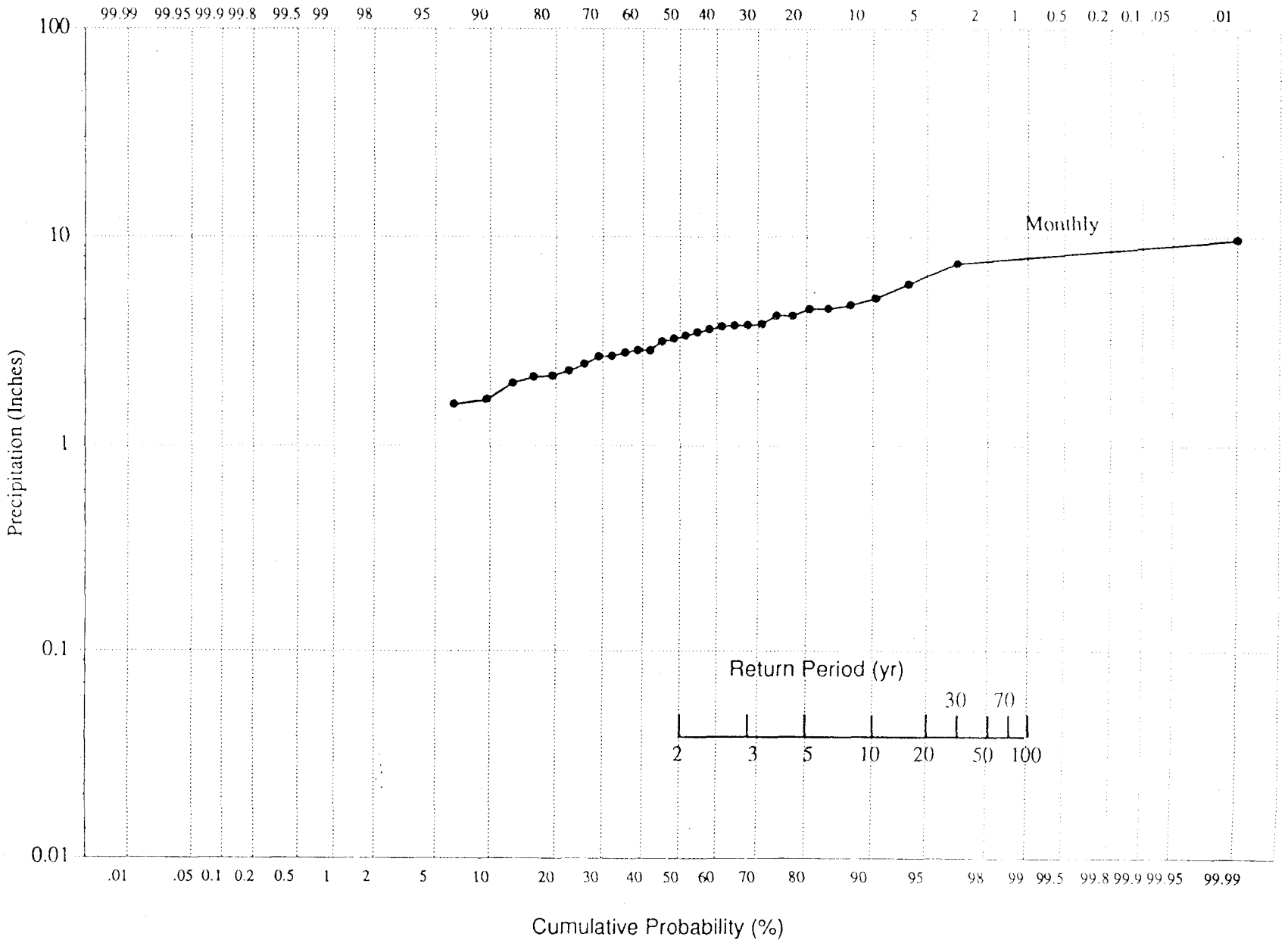


FIGURE 2.35. Daily Extreme Precipitation for SITE (1953-1977, 1987-1993).

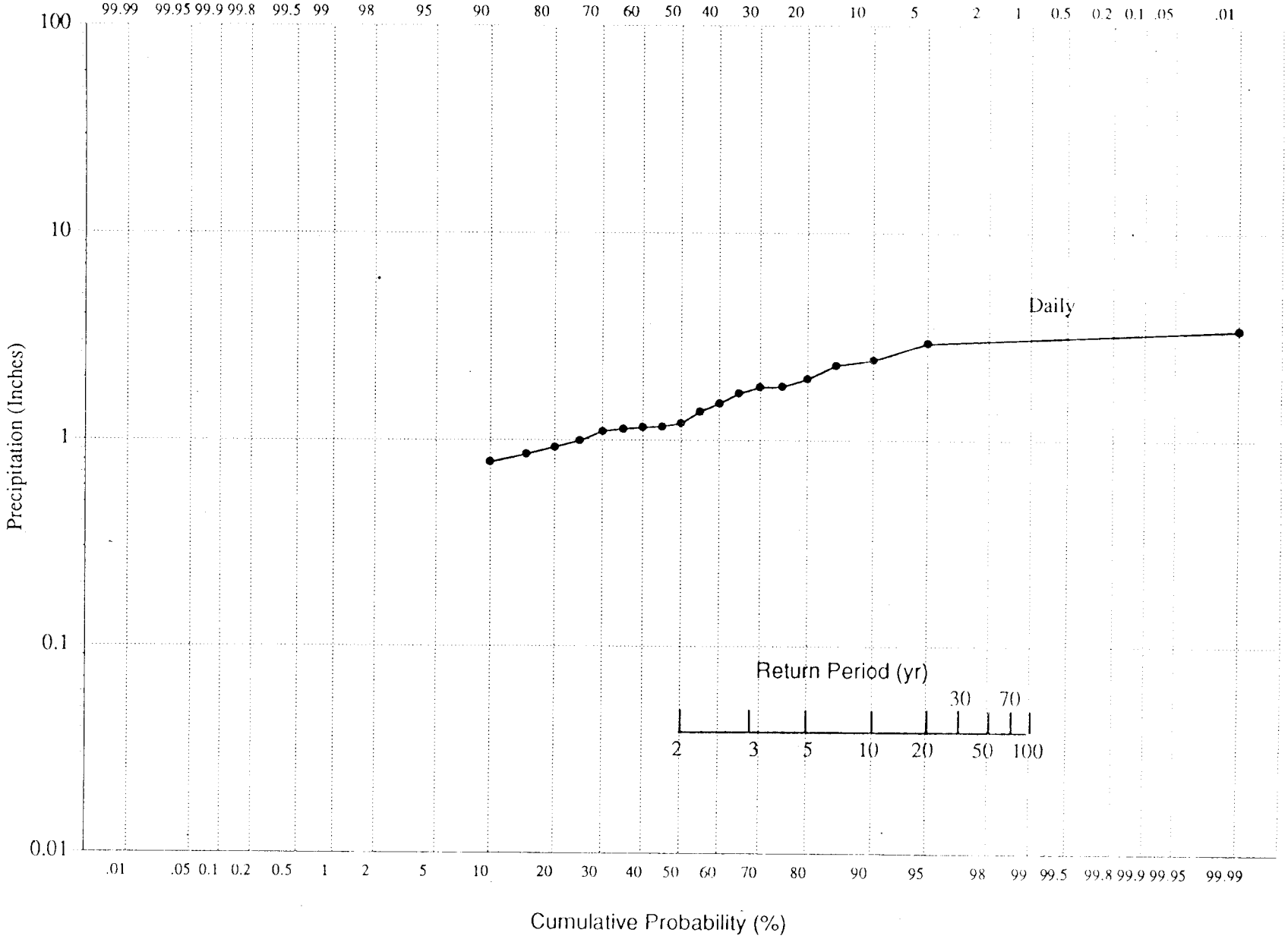


FIGURE 2.36. Shorter-Period Extreme Precipitation for SITE (1953-1977, 1987-1993).

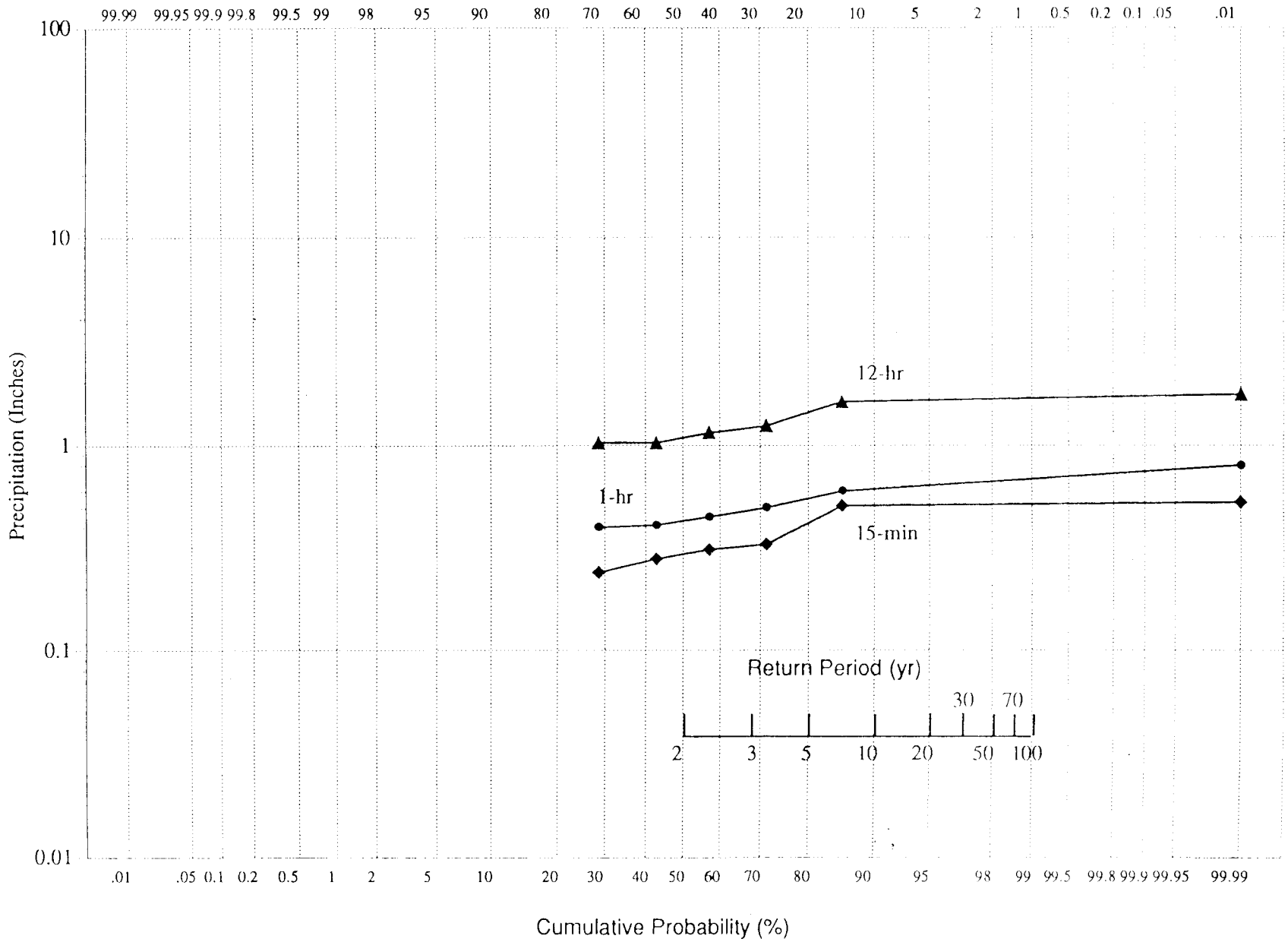


TABLE 2.35. Precipitation for Various Return Periods and Time Periods at SITE.

Return Period (yr)	Precipitation (in.)						
	15-min	1-hr	3-hr	12-hr	Daily	Monthly	Annual
SITE							
2	0.06	0.11	0.19	0.26	0.35	0.84	13.34
5	0.20	0.30	0.40	0.59	0.71	1.84	18.06
10	0.28	0.41	0.61	0.89	1.00	2.65	20.79
20	0.37	0.56	0.78	1.13	1.37	3.54	22.59
50	0.50	0.76	1.03	1.37	1.83	4.68	23.66
100	0.53	0.80	1.15	1.46	2.18	4.85	24.69

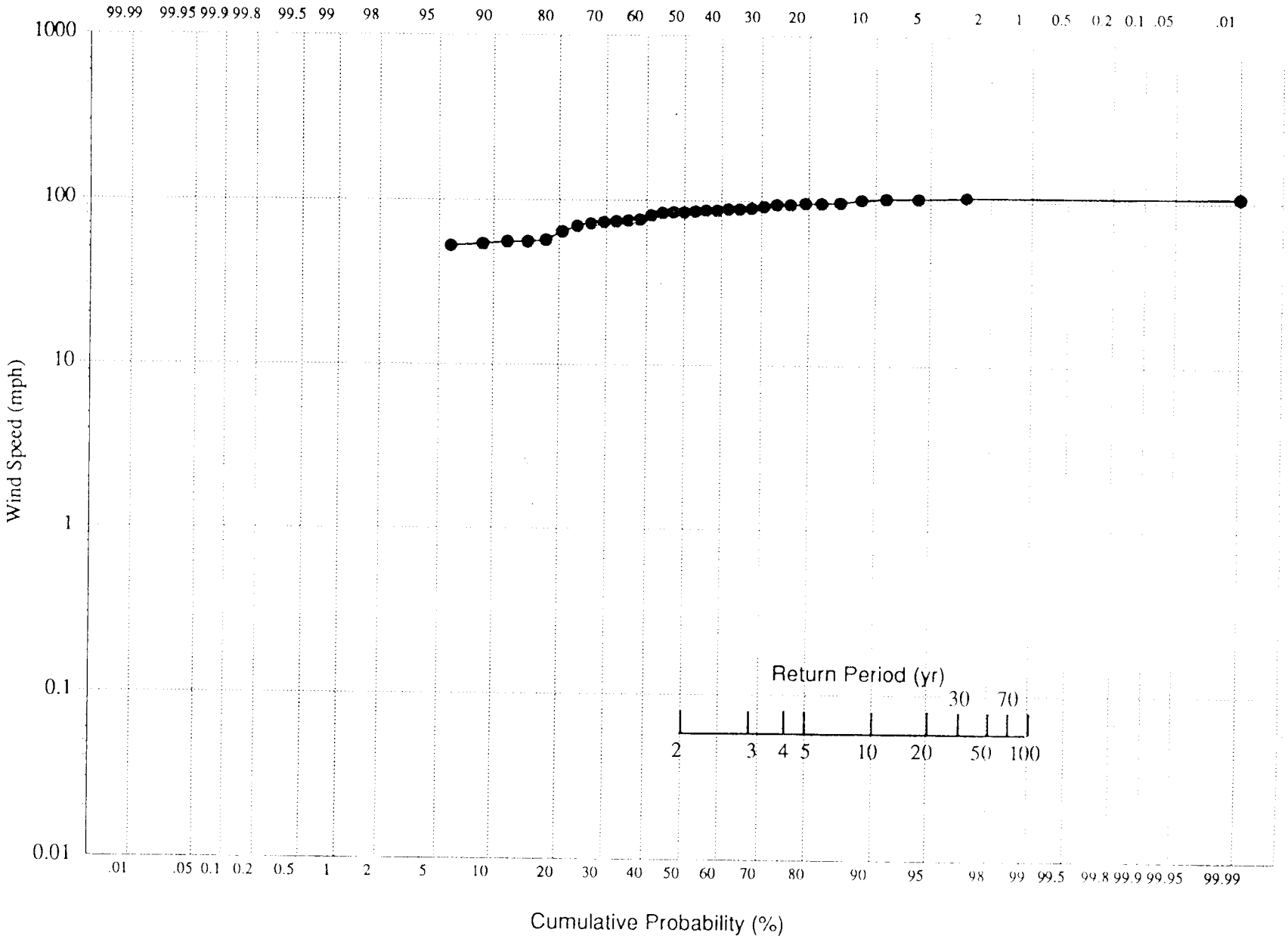
* 15 min, 30 min, 1-hr and 3-hr: 1984-1993.
* Daily, 1964-1977, 1984-1993.
* Annual, 1953-1977, 1984-993.

2.8.3 Annual Peak Wind Speeds

Figure 2.37 presents the annual peak wind speeds for each year (1953-1977 and 1984-1993) as a function of their location on the annual peak wind speed frequency distribution. The return period scale interprets the frequency distribution scale into the number of years that statistically would elapse until the recurrence of a particular annual peak wind speed.

Figure 2.37 shows the cumulative probability and return periods for peak wind speeds. As stated in Section 1.3.2, the monthly average peak wind speeds are a mixture of average peak wind gusts, collected between 1953 and 1977 and average monthly peak wind speeds collected between 1984 and 1993.

FIGURE 2.37. Peak Wind Speeds for SITE (1953-1977, 1984-1993).

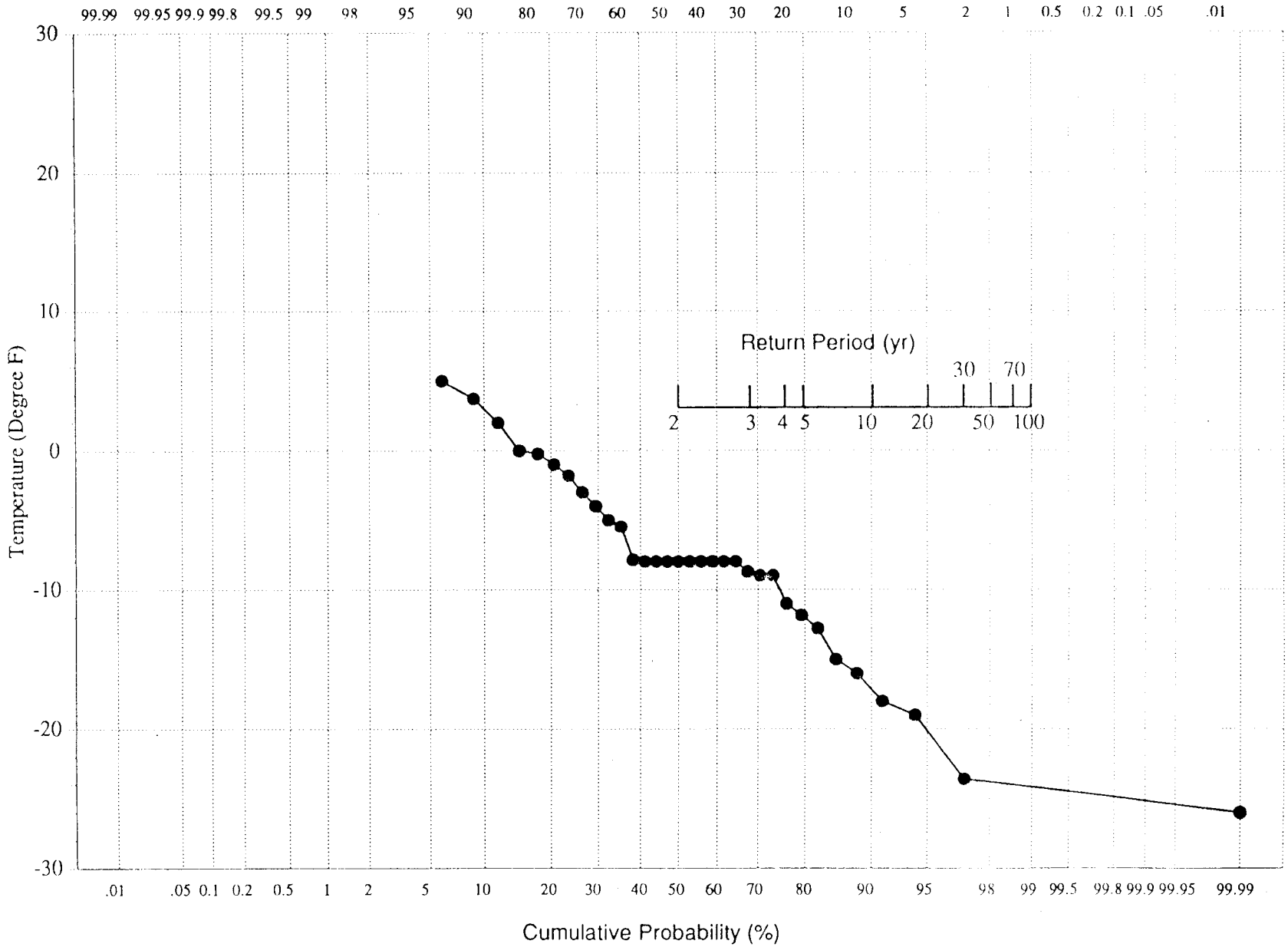


2.8.4 Extreme Maximum and Minimum Temperatures

Figure 2.38 presents the annual minimum temperature for each year (1953-1977 and 1984-1993) as a function of its location on the annual minimum frequency distribution. The return period scale interprets the frequency distribution scale into the number of years that statistically would elapse until the recurrence of a particular annual minimum temperature.

Figure 2.38 presents the cumulative probability and return periods for minimum temperatures at the Site. The data used in this analysis are the total available data collected from 1953-1977 and 1984-1993. It should be noted that the data are a compilation of minimums collected above a rooftop and in an open field (see Section 1.3.2). This analysis is not, therefore, representative of conditions either at the Building 123 or the West Buffer Zone locations.

FIGURE 2.38. Minimum Temperature for SITE (1953-1977, 1984-1993).



2.8.5 Historical Extremes

The data presented in Tables 2.36 through 2.47 were based on the 1964-1977 and 1984-1993 data sets only. Daily precipitation and temperature data were not available before 1964. Maximum and minimum extremes would be expected more frequently from the pre-May 1975 data due to the sensor location above a rooftop. Precipitation data from 1984-1986 were eliminated from the analysis (see Section 1.3.2).

ABLE 2-36. SITE Weather Extremes for January (1964-1977, 1984-1993).

	TEMPERATURE (DEG F)								MAXIMUM PRECIPITATION Water Equivalent (in.)	
	Maximum				Minimum					
Day	High	Year	Low	Year	High	Year	Low	Year	High	Year
1	57	1969	5	1974	42	1991	-4	1974	0.10	1965
2	52	1964	15	1974	40	1993	-9	1968	0.25	1971
3	54	1989	11	1974	39	1989	-4	1972	0.33	1972
4	61	1987	7	1971	45	1987	-12	1972	0.06	1970
5	56	1965	8	1974	42	1985	-8	1974	0.05	1974
6	63	1965	15	1971	40	1965	-5	1974	0.10	1972
7	65	1969	12	1973	43	1966	0	1973	0.10	1992
8	65	1966	8	1973	44	1966	-5	1973	0.05	1974
9	55	1990	7	1973	46	1990	-7	1973	0.02	1989
10	64	1990	10	1993	51	1990	-1	1993	0.05	1964
11	61	1967	18	1975	39	1967	-3	1964	0.10	1964
12	60	1969	13	1964	42	1987	-5	1964	0.50	1972
13	58	1969	17	1993	45	1990	-8	1964	0.00	1992
14	59	1974	6	1984	42	1973	-5	1972	0.28	1967
15	65	1974	21	1987	47	1974	-3	1972	0.05	1990
16	69	1974	13	1987	46	1974	-1	1987	0.13	1967
17	62	1971	10	1984	42	1976	-9	1984	0.20	1974
18	60	1965	18	1984	41	1972	-12	1984	0.50	1974
19	61	1971	19	1984	44	1972	2	1984	0.14	1991
20	66	1971	11	1966	46	1969	-1	1966	0.50	1973
21	61	1969	15	1985	44	1969	-4	1966	0.34	1975
22	59	1967	21	1985	47	1967	6	1966	0.20	1968
23	60	1986	19	1969	41	1976	6	1969	0.21	1988
24	67	1968	25	1964	42	1992	12	1969	0.04	1976
25	60	1968	17	1991	40	1971	3	1966	0.23	1967
26	62	1975	14	1972	41	1987	3	1972	0.30	1973
27	62	1970	22	1973	47	1987	1	1972	0.01	1975
28	65	1988	32	1990	48	1988	4	1991	0.45	1989
29	62	1976	24	1972	50	1971	-5	1991	0.01	1991
30	62	1971	9	1985	53	1971	-6	1985	0.33	1965
31	61	1992	3	1985	47	1989	-5	1985	0.28	1965
Month	49	1986	28	1984	31.8	1986	11.1	1984	1.12	1974

verage Temperature (1964-1993) Max.: 40.2 Min. 19.4 Mean 32.3 Deg. F

Temperatures	*Deg. F*	*Year*
Warmest January	40.2	1986
Coldest January	19.4	1984
Most days=<32 Deg. F	20	1964
Fewest days=<32 Deg. F	3	1986
Most days =< 0 Deg. F	2	1985
Most days precipitation>=0.01 in	7	1987
Most days precipitation>=0.1 in	3	many
Least January precipitation	0	84,85,86

SITE4.XLS-table-ts-2/9/95

TABLE 2-37. SITE Weather Extremes for February (1964-1977, 1984-1993).

	TEMPERATURE (DEG F)								MAXIMUM PRECIPITATION Water Equivalent (in.)	
	Maximum				Minimum					
Day	High	Year	Low	Year	High	Year	Low	Year	High	Year
1	61	1984	7	1985	44	1991	-9	1985	0.00	1993
2	57	1971	11	1985	43	1987	0	1972	0.07	1990
3	53	1991	15	1985	40	1970	2	1985	0.95	1969
4	59	1967	18	1985	41	1967	-4	1985	1.83	1984
5	56	1965	6	1976	42	1965	-3	1975	0.45	1967
6	56	1970	8	1989	40	1984	-2	1975	0.27	1970
7	63	1987	23	1986	45	1987	5	1989	0.23	1970
8	61	1976	17	1989	45	1976	1	1989	0.28	1968
9	65	1976	13	1986	43	1976	2	1975	0.15	1973
10	60	1970	23	1986	45	1971	2	1986	0.45	1969
11	58	1976	17	1986	44	1990	0	1986	0.79	1974
12	59	1975	24	1965	43	1976	6	1986	0.55	1969
13	62	1971	21	1966	43	1971	6	1964	0.00	1991
14	60	1967	9	1990	37	1971	0	1990	0.63	1984
15	64	1971	15	1990	47	1986	-3	1993	0.46	1984
16	66	1970	-3	1993	47	1970	-8	1993	0.08	1984
17	66	1970	17	1993	46	1986	-6	1993	0.56	1993
18	56	1986	29	1984	45	1986	13	1975	0.33	1965
19	64	1972	26	1967	43	1968	13	1975	0.40	1990
20	63	1972	20	1964	45	1972	7	1964	0.17	1990
21	58	1988	26	1971	42	1992	10	1971	0.12	1972
22	64	1972	25	1964	38	1986	10	1975	0.07	1974
23	58	1970	15	1965	41	1976	0	1964	0.08	1984
24	62	1986	22	1993	51	1986	14	1967	1.04	1984
25	65	1986	12	1964	49	1986	0	1964	0.40	1992
26	62	1965	27	1984	44	1965	-2	1964	0.12	1970
27	62	1988	22	1987	45	1965	9	1987	0.33	1976
28	71	1972	28	1990	47	1992	14	1964	0.07	1991
29	64	1972	51	1976	44	1992	24	1976	0.53	1969
Month	50.4	1970	32.2	1964	33.2	1991	13.6	1964	1.28	1971

Average Temperature (1964-1993) **Max.** **40.4** Min. 22.9 Mean **34.0**

Temperatures	*Deg. F*	*Year*
Warmest February	40.4	1991
Coldest Febuary	22.9	1964
Most days=<32 Deg. F	24	1964
Fewest days=<32 Deg. F	1	1985,1993
Most days =< 0 Deg. F	9	1971
Most days precipitation>=0.01 in	2	1970
Most days precipitation>=0.1 in	4	65,68
Least Febuary precipitation	0	1992

SITE4.XLS-table-ss-2/9/95

ABLE 2-38. SITE Weather Extremes for March (1964-1977, 1984-1993).

	TEMPERATURE (DEG F)								MAXIMUM PRECIPITATION	
	Maximum				Minimum				Water Equivalent (In.)	
Day	High	Year	Low	Year	High	Year	Low	Year	High	Year
1	68	1967	24	1965	51	1967	10	1965	0.44	1987
2	67	1974	21	1965	45	1992	8	1965	0.27	1966
3	56	1972	18	1976	41	1991	-2	1989	0.75	1972
4	62	1986	9	1989	47	1991	-5	1989	0.50	1967
5	63	1968	24	1967	44	1987	3	1976	0.34	1974
6	73	1972	23	1964	55	1972	9	1964	0.17	1993
7	61	1970	23	1964	50	1970	5	1969	0.25	1968
8	66	1986	17	1969	53	1986	-3	1969	0.26	1990
9	74	1972	22	1969	54	1989	0	1969	0.08	1970
10	77	1972	22	1970	58	1989	3	1969	0.40	1966
11	71	1972	24	1970	54	1989	4	1969	0.35	1968
12	66	1972	17	1993	46	1989	9	1993	0.05	1970
13	67	1966	23	1969	46	1987	8	1993	0.02	1976
14	65	1966	34	1964	46	1966	9	1969	0.35	1970
15	66	1966	31	1988	44	1966	17	1969	0.42	1974
16	70	1966	24	1988	48	1972	14	1988	0.68	1964
17	70	1974	22	1965	53	1974	3	1965	0.53	1987
18	72	1972	12	1965	43	1969	-2	1965	0.50	1964
19	69	1975	13	1965	44	1966	-3	1965	0.60	1991
20	68	1975	22	1974	50	1988	3	1965	0.42	1991
21	68	1988	36	1968	53	1988	6	1968	0.60	1973
22	71	1972	30	1966	46	1989	14	1974	0.36	1992
23	72	1967	16	1965	48	1970	5	1965	0.18	1967
24	67	1967	17	1965	49	1993	-3	1965	0.03	1970
25	71	1972	18	1965	50	1993	-5	1965	0.20	1992
26	82	1971	34	1970	49	1989	9	1965	0.24	1964
27	73	1971	21	1975	48	1986	4	1975	0.04	1989
28	70	1968	21	1975	50	1968	-1	1975	0.50	1972
29	74	1967	29	1987	50	1968	5	1975	0.56	1972
30	80	1971	31	1973	50	1971	12	1987	0.18	1968
31	73	1969	26	1970	47	1969	21	1975	0.05	1992
Month	57.3	1972	37.7	1965	36.4	1986	18.2	1965	4.7	1970

verage Temperature (1964-1993) Max. 46.6 Min. 28.0 Mean 38.3 Deg. F

Temperatures	*Deg. F*	*Year*
Warmest March	46.5	1972
Coldest March	28.0	1965
Most days=<32 Deg. F	19	1964
Fewest days=<32 Deg. F	2	1986
Most days =< 0 Deg. F	-	-
Most days precipitation>=0.01 in	12	1965,1970
Most days precipitation>=0.1 in	11	1970
Least March precipitation	0.13	1966

TABLE 2-39. SITE Weather Extremes for April (1964-1977, 1984-1993).

	TEMPERATURE (DEG F)								MAXIMUM PRECIPITATION	
	Maximum				Minimum				Water Equivalent (in.)	
Day	High	Year	Low	Year	High	Year	Low	Year	High	Year
1	65	1968	20	1975	44	1991	8	1975	0.49	1986
2	67	1969	30	1984	41	1991	5	1975	0.21	1967
3	67	1969	29	1970	49	1988	20	1968	0.45	1973
4	69	1967	32	1964	51	1992	17	1968	0.11	1991
5	73	1969	34	1990	55	1991	22	1964	0.25	1972
6	73	1988	38	1964	49	1988	19	1990	0.35	1972
7	73	1988	25	1973	56	1988	15	1973	0.20	1966
8	73	1967	27	1973	46	1971	8	1973	0.20	1971
9	70	1972	25	1973	49	1970	5	1973	0.06	1967
10	78	1971	31	1989	54	1992	14	1989	0.07	1975
11	74	1968	30	1975	56	1972	25	1989	0.15	1970
12	70	1971	29	1991	51	1988	24	1991	0.00	1991
13	73	1992	36	1991	55	1992	19	1991	0.25	1967
14	75	1971	34	1972	45	1992	24	1991	0.20	1971
15	74	1971	35	1973	52	1971	23	1973	0.30	1965
16	76	1964	39	1969	55	1987	27	1973	0.02	1965
17	75	1987	33	1968	60	1987	25	1968	0.04	1993
18	75	1987	33	1968	56	1987	16	1966	0.10	1989
19	72	1987	22	1966	52	1965	13	1966	0.45	1973
20	79	1965	35	1987	58	1989	14	1966	0.10	1993
21	80	1965	37	1984	60	1989	27	1966	0.17	1967
22	77	1989	35	1988	65	1989	25	1967	0.17	1968
23	76	1989	38	1973	63	1973	24	1968	0.04	1974
24	77	1974	41	1993	54	1987	29	1967	0.50	1973
25	78	1975	36	1973	56	1970	29	1973	0.15	1969
26	76	1974	36	1971	59	1970	28	1973	0.00	1992
27	75	1992	36	1976	61	1970	30	1969	0.25	1969
28	74	1967	43	1989	57	1992	25	1966	0.16	1987
29	76	1967	38	1990	52	1992	26	1989	0.30	1967
30	81	1992	34	1989	65	1992	25	1990	0.45	1972
Month	62.4	1969	46.7	1973	42.5	1992	30.0	1973	4.73	1973

Average Temperature (1964-1993) Max. 52.0 Min. 38.4 Mean 46.1 Deg. F

Temperatures	*Deg. F*	*Year*
Warmest April	52.0	1992
Coldest April	38.4	1973
Most days=<32 Deg. F	8	1973
Fewest days=<32 Deg. F	1	many
Most days =< 0 Deg. F	-	-
Most days precipitation>=0.01 in	13	1990
Most days precipitation>=0.1 in	12	1973
Least April precipitation	0.34	1989

TABLE 2-40. SITE Weather Extremes for May (1964-1977, 1984-1993).

	TEMPERATURE (DEG F)								MAXIMUM PRECIPITATION	
	Maximum				Minimum				Water Equivalent (in.)	
Day	High	Year	Low	Year	High	Year	Low	Year	High	Year
1	80	1965	34	1984	56	1965	26	1970	0.11	1976
2	80	1965	44	1973	51	1986	27	1973	0.13	1967
3	80	1971	43	1987	56	1986	30	1991	0.10	1966
4	80	1966	41	1991	53	1976	31	1991	0.11	1988
5	82	1966	38	1967	59	1966	31	1991	0.25	1971
6	83	1966	42	1973	53	1966	31	1967	0.50	1970
7	82	1966	38	1969	60	1966	32	1964	0.05	1974
8	82	1974	34	1969	57	1992	34	1969	0.01	1988
9	77	1967	40	1969	53	1984	29	1990	0.03	1975
10	78	1991	43	1969	59	1991	32	1968	0.00	1993
11	78	1991	44	1969	55	1991	30	1966	0.11	1993
12	82	1974	39	1966	60	1987	28	1966	0.23	1965
13	79	1988	37	1967	58	1988	30	1967	0.06	1984
14	78	1964	44	1989	61	1988	29	1967	0.40	1968
15	82	1975	49	1969	60	1984	36	1970	0.20	1965
16	82	1988	40	1986	57	1972	33	1986	0.52	1975
17	86	1964	41	1969	63	1988	33	1968	0.07	1993
18	83	1970	47	1969	65	1970	36	1968	0.09	1974
19	84	1974	46	1988	60	1992	34	1968	0.41	1974
20	83	1970	44	1987	61	1984	37	1967	0.10	1967
21	83	1964	45	1969	61	1986	38	1975	0.30	1967
22	87	1967	43	1969	64	1986	39	1975	0.70	1971
23	84	1967	45	1969	67	1989	39	1975	0.25	1968
24	84	1964	48	1968	60	1967	40	1976	0.12	1985
25	82	1972	49	1992	60	1964	39	1968	0.10	1965
26	79	1974	54	1965	61	1969	32	1989	0.04	1991
27	85	1974	48	1967	61	1974	36	1992	0.11	1984
28	89	1974	50	1975	65	1989	36	1973	0.02	1987
29	84	1974	46	1975	62	1989	33	1975	0.15	1968
30	81	1984	39	1964	63	1984	33	1973	0.05	1965
31	82	1972	46	1969	62	1965	36	1964	0.00	1992
Month	74.1	1974	48.0	1969	48.5	1974	41.5	1968	9.7	1969

Average Temperature (1964-1993) Max. 61.3 Min. 48.0 Mean 55.1 Deg. F

Temperatures	*Deg. F*	*Year*
Warmest May	61.3	1974
Coldest May	48.0	1969
Most days=<32 Deg. F	1	1990
Fewest days=<32 Deg. F	-	-
Most days =< 0 Deg. F	-	-
Most days precipitation>=0.01 in	14	1992
Most days precipitation>=0.1 in	9	67,69
Least May precipitation	0.08	1974

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TABLE 2-41. SITE Weather Extremes for June (1964-1977, 1984-1993).

	TEMPERATURE (DEG F)								MAXIMUM PRECIPITATION	
	Maximum				Minimum				Water Equivalent (in.)	
Day	High	Year	Low	Year	High	Year	Low	Year	High	Year
1	87	1972	47	1964	58	1972	39	1970	0.20	1988
2	83	1966	57	1964	61	1971	39	1964	0.18	1964
3	85	1968	57	1989	66	1986	42	1993	0.70	1973
4	85	1990	49	1989	61	1974	37	1993	1.04	1992
5	88	1969	56	1965	63	1987	43	1965	0.65	1971
6	85	1969	54	1974	63	1987	43	1992	0.92	1990
7	86	1988	58	1993	65	1988	44	1993	0.25	1967
8	84	1973	44	1974	66	1988	38	1974	1.04	1992
9	89	1973	50	1975	60	1973	41	1975	0.34	1992
10	89	1973	47	1975	64	1973	35	1975	0.30	1970
11	85	1972	49	1970	61	1973	41	1975	0.16	1993
12	84	1968	60	1969	61	1972	47	1969	0.11	1965
13	85	1968	55	1969	65	1987	35	1969	0.45	1990
14	89	1974	44	1969	63	1987	36	1969	0.09	1967
15	88	1993	55	1969	62	1971	40	1976	0.05	1975
16	91	1971	51	1969	65	1989	46	1969	0.35	1970
17	92	1971	51	1993	64	1971	42	1976	0.50	1970
18	90	1974	48	1976	64	1974	39	1976	0.40	1973
19	92	1974	67	1992	66	1974	41	1976	0.10	1964
20	94	1968	68	1969	75	1989	42	1973	0.10	1987
21	90	1974	61	1964	67	1974	44	1989	0.25	1968
22	93	1968	60	1989	72	1971	44	1989	0.31	1984
23	99	1971	59	1967	67	1971	46	1967	0.31	1974
24	96	1971	51	1967	74	1990	42	1993	0.90	1970
25	98	1971	61	1992	73	1990	47	1968	0.35	1973
26	95	1971	62	1969	72	1971	45	1968	0.25	1970
27	92	1971	68	1992	71	1974	48	1976	0.55	1972
28	95	1974	67	1967	75	1990	54	1965	0.73	1975
29	92	1974	59	1987	72	1984	51	1987	0.67	1970
30	92	1990	64	1987	66	1990	49	1968	1.06	1970
Month	83.7	1971	68.0	1969	59.9	1971	49.8	1969	4.79	1969

Average Temperature (1964-1993) Max. 71.8 Min. 58.9 Mean 64.4 Deg. F

Temperatures	*Deg. F*	*Year*
Warmest June	71.8	1971
Coldest June	58.9	1969
Most days=<32 Deg. F	-	-
Fewest days=<32 Deg. F	-	-
Most days =< 0 Deg. F	-	-
Most days precipitation>=0.01 in	16	1965
Most days precipitation>=0.1 in	10	67,69
Least June precipitation	0.12	1990

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ABLE 2-42. SITE Weather Extremes for July (1964-1977, 1984-1993).

	TEMPERATURE (DEG F)								MAXIMUM PRECIPITATION	
	Maximum				Minimum				Water Equivalent (in.)	
Day	High	Year	Low	Year	High	Year	Low	Year	High	Year
1	94	1973	68	1992	70	1990	48	1968	0.20	1975
2	94	1974	61	1972	76	1990	46	1992	0.15	1965
3	94	1964	50	1972	72	1969	47	1972	0.60	1973
4	95	1966	54	1972	71	1986	46	1972	0.38	1993
5	95	1973	63	1968	70	1991	47	1972	1.41	1986
6	97	1973	70	1986	73	1973	51	1968	0.33	1990
7	94	1989	73	1988	72	1989	51	1993	0.25	1973
8	93	1974	64	1990	77	1989	54	1988	0.30	1973
9	93	1966	72	1988	75	1989	51	1988	0.50	1973
10	95	1971	72	1984	68	1966	56	1984	0.30	1967
11	98	1971	68	1993	68	1971	53	1993	0.48	1975
12	102	1971	58	1987	69	1971	46	1987	0.32	1991
13	95	1972	61	1973	69	1988	47	1990	0.49	1993
14	89	1972	56	1973	72	1968	47	1973	2.30	1967
15	92	1966	68	1972	70	1968	48	1973	0.43	1972
16	93	1966	58	1992	72	1965	51	1992	0.48	1969
17	93	1971	64	1972	71	1991	38	1975	0.30	1969
18	89	1974	67	1973	69	1990	52	1972	0.93	1968
19	92	1964	55	1988	69	1984	46	1988	0.25	1986
20	90	1968	60	1973	71	1964	50	1988	0.58	1971
21	93	1964	57	1990	71	1970	47	1990	0.48	1971
22	96	1964	63	1990	68	1964	47	1990	0.21	1991
23	92	1964	56	1991	70	1964	50	1990	0.90	1971
24	87	1968	59	1991	66	1986	53	1991	0.20	1970
25	92	1974	65	1991	67	1987	51	1973	0.55	1973
26	93	1966	61	1971	72	1969	49	1971	1.10	1971
27	93	1964	72	1965	69	1987	53	1971	1.37	1965
28	88	1969	70	1990	69	1987	50	1971	0.47	1976
29	90	1972	52	1971	68	1987	44	1971	0.50	1974
30	96	1972	62	1989	71	1987	45	1971	0.55	1976
31	92	1966	61	1968	71	1993	49	1968	0.70	1973
Month	88.0	1964	74.1	1990	64.1	1966	56.7	1973	5.1	1965

verage Temperature (1964-1993) Max. 75.9 Min. 66.1 Mean 70.5 Deg. F

Temperatures	*Deg. F*	*Year*
Warmest July	75.9	1966
Coldest July	66.1	1992
Most days=<32 Deg. F	-	-
Fewest days=<32 Deg. F	-	-
Most days =< 0 Deg. F	-	-
Most days precipitation>=0.01 in	17	1990
Most days precipitation>=0.1 in	10	1965
Least July precipitation	0.3	1964

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TABLE 2-43. SITE Weather Extremes for August (1964-1977, 1984-1993).

	TEMPERATURE (DEG F)								MAXIMUM PRECIPITATION	
	Maximum				Minimum				Water Equivalent (in.)	
Day	High	Year	Low	Year	High	Year	Low	Year	High	Year
1	91	1970	70	1976	66	1964	51	1968	0.30	1973
2	92	1970	60	1976	70	1987	53	1976	0.12	1988
3	85	1989	59	1993	70	1989	48	1993	0.13	1967
4	90	1968	55	1988	69	1989	51	1993	0.60	1969
5	92	1969	62	1966	67	1987	53	1993	2.75	1969
6	96	1969	69	1989	68	1975	50	1993	3.40	1969
7	90	1975	67	1989	73	1990	52	1989	1.00	1969
8	97	1969	66	1966	69	1990	53	1989	0.28	1965
9	89	1972	66	1968	71	1992	53	1974	0.35	1989
10	95	1972	55	1968	72	1970	51	1974	0.50	1971
11	96	1972	64	1990	70	1987	51	1968	0.35	1971
12	92	1972	63	1991	70	1965	51	1992	0.30	1968
13	93	1970	63	1975	65	1972	51	1966	0.30	1989
14	89	1973	67	1968	68	1988	51	1975	0.46	1989
15	88	1966	66	1970	67	1988	49	1975	0.68	1991
16	93	1966	68	1975	70	1986	52	1975	1.00	1969
17	89	1974	64	1992	67	1974	54	1992	1.09	1986
18	90	1986	71	1992	70	1970	47	1967	1.16	1988
19	96	1964	66	1965	69	1986	52	1967	0.82	1988
20	92	1973	70	1964	72	1987	50	1964	0.25	1987
21	88	1971	63	1965	65	1976	50	1966	0.71	1976
22	89	1971	60	1987	65	1973	49	1966	0.45	1975
23	89	1971	54	1987	68	1991	50	1987	1.20	1968
24	89	1967	53	1992	69	1991	48	1992	0.50	1968
25	89	1970	57	1992	68	1991	47	1975	0.45	1992
26	91	1966	61	1987	68	1973	47	1992	0.40	1964
27	91	1973	61	1993	71	1990	46	1976	1.10	1967
28	88	1970	66	1988	71	1990	48	1988	1.50	1975
29	89	1970	55	1968	72	1984	48	1968	0.98	1975
30	87	1990	55	1993	71	1990	46	1993	0.75	1964
31	88	1964	54	1967	69	1989	47	1967	1.15	1967
Month	84.3	1973	73.7	1993	62.5	1984	56.2	1967	3.69	1967

Average Temperature (1964-1993) Max. 72.6 Min. 65.2 Mean 68.9 Deg. F

Temperatures	*Deg. F*	*Year*
Warmest August	72.6	1970
Coldest August	65.2	1992
Most days=<32 Deg. F	-	-
Fewest days=<32 Deg. F	-	-
Most days =< 0 Deg. F	-	-
Most days precipitation>=0.01 in	14	1991
Most days precipitation>=0.1 in	7	72,67,87
Least August precipitation	0.22	1974

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ABLE 2-44. SITE Weather Extremes for September (1964-1977, 1984-1993).

	TEMPERATURE (DEG F)								MAXIMUM PRECIPITATION	
	Maximum				Minimum				Water Equivalent (in.)	
Day	High	Year	Low	Year	High	Year	Low	Year	High	Year
1	90	1969	54	1972	66	1987	46	1972	1.11	1991
2	86	1971	46	1974	64	1971	37	1974	0.50	1989
3	85	1970	50	1968	64	1967	41	1968	0.96	1989
4	84	1970	60	1971	63	1990	42	1971	1.30	1965
5	86	1969	60	1965	63	1989	41	1968	0.79	1965
6	89	1964	71	1987	69	1984	48	1967	0.20	1972
7	87	1974	58	1965	68	1988	48	1971	0.70	1966
8	88	1970	60	1989	63	1966	44	1992	1.68	1974
9	87	1974	45	1989	63	1964	39	1989	0.44	1986
10	91	1974	45	1989	68	1974	41	1970	0.59	1975
11	87	1968	61	1974	67	1976	39	1974	1.80	1970
12	83	1990	39	1974	66	1992	33	1974	0.21	1989
13	89	1990	43	1988	62	1992	38	1974	0.25	1969
14	83	1968	50	1988	62	1965	41	1988	0.60	1967
15	79	1990	50	1973	66	1992	38	1973	1.00	1967
16	83	1972	39	1971	66	1992	26	1965	0.62	1969
17	86	1972	33	1971	64	1972	26	1965	1.13	1993
18	85	1970	36	1971	63	1984	26	1971	0.49	1987
19	87	1970	43	1965	66	1984	24	1971	0.50	1992
20	85	1970	41	1965	61	1992	31	1965	0.25	1970
21	81	1966	35	1971	62	1966	32	1971	0.27	1967
22	83	1967	50	1971	57	1967	30	1971	0.05	1972
23	84	1966	37	1965	66	1992	33	1965	0.40	1969
24	83	1966	44	1984	66	1992	33	1984	0.75	1968
25	80	1974	46	1970	62	1987	32	1984	0.41	1992
26	80	1974	51	1973	63	1974	36	1964	0.03	1966
27	81	1972	43	1976	58	1989	33	1984	2.94	1987
28	83	1969	32	1984	65	1991	29	1984	0.25	1967
29	83	1969	43	1965	62	1969	31	1984	0.05	1971
30	82	1967	46	1966	63	1989	34	1965	0.29	1965
Month	76.3	1969	62.3	1965	55.4	1990	44.1	1965	4.53	1976

verage Temperature (1964-1993) Max. 65.5 Min. 53.2 Mean 60.3 Deg. F

Temperatures	*Deg. F*	*Year*
Warmest September	65.5	1969
Coldest September	53.2	1965
Most days=<32 Deg. F	2	1971
Fewest days=<32 Deg. F	1	1965,1984
Most days =< 0 Deg. F	-	-
Most days precipitation>=0.01 in	13	90,65,76
Most days precipitation>=0.1 in	7	89,71,76
Least September precipitation	0	1992

TABLE 2-45. SITE Weather Extremes for October (1964-1977, 1984-1993).

	TEMPERATURE (DEG F)								MAXIMUM PRECIPITATION	
	Maximum				Minimum				Water Equivalent (in.)	
Day	High	Year	Low	Year	High	Year	Low	Year	High	Year
1	81	1964	58	1988	60	1992	36	1966	0.40	1967
2	80	1974	54	1971	61	1992	37	1989	0.22	1988
3	82	1967	39	1986	61	1987	31	1969	0.50	1972
4	81	1970	40	1991	63	1987	30	1991	0.60	1990
5	79	1970	49	1991	64	1970	31	1991	0.05	1968
6	79	1975	41	1974	62	1993	30	1976	0.15	1972
7	78	1975	35	1970	60	1965	24	1970	0.42	1988
8	75	1974	32	1990	61	1965	25	1970	0.65	1990
9	80	1965	32	1993	62	1965	24	1993	0.78	1991
10	78	1971	35	1973	56	1989	26	1987	0.37	1970
11	77	1967	31	1969	65	1989	20	1969	0.36	1991
12	78	1991	24	1969	60	1989	7	1969	0.35	1973
13	77	1992	24	1969	63	1989	7	1969	0.10	1973
14	82	1968	40	1987	56	1968	4	1969	0.28	1969
15	76	1965	33	1969	56	1964	23	1969	0.83	1967
16	82	1991	31	1989	65	1991	21	1969	0.21	1975
17	78	1974	31	1989	53	1974	24	1969	0.07	1992
18	74	1974	34	1969	48	1974	23	1976	0.19	1969
19	74	1974	34	1984	52	1992	21	1976	0.64	1988
20	75	1974	31	1984	52	1966	26	1984	1.46	1986
21	77	1975	27	1984	58	1992	24	1984	0.71	1965
22	71	1973	31	1984	58	1991	26	1984	0.48	1991
23	80	1973	37	1984	51	1992	28	1984	0.75	1965
24	76	1965	31	1975	51	1992	19	1975	0.75	1965
25	72	1968	38	1984	52	1989	25	1975	0.41	1976
26	76	1966	35	1969	58	1990	32	1970	0.23	1965
27	74	1966	38	1976	50	1966	26	1967	0.26	1968
28	77	1968	28	1971	54	1968	12	1991	0.25	1964
29	81	1968	18	1991	59	1990	6	1991	0.99	1989
30	76	1968	14	1991	57	1990	7	1991	0.32	1989
31	64	1990	26	1972	55	1990	6	1991	1.00	1965
Month	67.3	1965	46.6	1969	46.8	1965	31.1	1969	4.83	1969

Average Temperature (1964-1993) **Max.** **57.1** **Min.** **38.8** **Mean** **50.8** **Deg. F**

Temperatures	*Deg. F*	*Year*
Warmest October	57.1	1965
Coldest October	38.8	1969
Most days=<32 Deg. F	8	1969
Fewest days=<32 Deg. F	1	many
Most days =< 0 Deg. F	-	-
Most days precipitation>=0.01 in	11	1969,1993
Most days precipitation>=0.1 in	10	1969
Least October precipitation	0.06	1975

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ABLE 2-46. SITE Weather Extremes for November (1964-1977, 1984-1993).

	TEMPERATURE (DEG F)								MAXIMUM PRECIPITATION	
	Maximum				Minimum				Water Equivalent (in.)	
Day	High	Year	Low	Year	High	Year	Low	Year	High	Year
1	69	1965	21	1991	56	1965	6	1991	0.37	1966
2	68	1984	14	1991	57	1965	-1	1991	0.50	1976
3	64	1975	24	1990	51	1987	9	1967	0.56	1991
4	67	1965	25	1973	52	1965	12	1967	0.42	1988
5	64	1969	21	1993	53	1965	15	1967	0.14	1993
6	69	1970	30	1990	52	1975	14	1990	1.15	1991
7	68	1964	33	1968	49	1965	11	1990	0.27	1987
8	70	1964	35	1966	50	1991	11	1966	0.10	1992
9	66	1964	35	1975	52	1965	7	1966	0.77	1968
10	68	1973	21	1986	52	1989	15	1986	0.46	1968
11	68	1973	40	1975	58	1989	19	1986	0.07	1989
12	71	1973	27	1986	55	1989	8	1986	0.74	1989
13	66	1984	30	1972	49	1984	10	1986	0.71	1975
14	71	1990	30	1993	58	1990	16	1974	0.50	1968
15	71	1966	24	1964	55	1965	14	1989	0.28	1972
16	67	1966	29	1991	51	1992	10	1989	0.53	1965
17	62	1990	28	1964	45	1990	16	1971	0.25	1973
18	60	1965	25	1971	49	1965	13	1969	0.78	1967
19	71	1989	27	1975	52	1989	19	1975	0.40	1972
20	65	1968	25	1975	45	1965	10	1975	0.19	1970
21	70	1974	27	1992	49	1986	14	1975	0.29	1987
22	64	1968	27	1991	46	1965	14	1970	0.52	1986
23	61	1965	31	1992	51	1965	5	1993	0.38	1987
24	67	1990	7	1993	56	1990	-3	1993	1.97	1992
25	72	1970	14	1993	54	1990	-3	1993	0.28	1992
26	57	1970	26	1987	35	1970	16	1993	0.42	1987
27	59	1991	26	1972	37	1991	11	1986	0.33	1964
28	64	1986	28	1972	37	1993	8	1972	0.07	1971
29	67	1970	23	1991	47	1970	4	1975	0.35	1968
30	62	1964	14	1991	43	1970	5	1975	2.10	1967
Month	55.7	1965	39.7	1992	46.2	1965	25.6	1972	2	1972

verage Temperature (1964-1993) Max. 51.0 Min. 33.4 Mean 39.9 Deg. F

Temperatures	*Deg. F*	*Year*
Warmest November	51.0	1965
Coldest November	33.4	1972
Most days=<32 Deg. F	14	1972
Fewest days=<32 Deg. F	1	1965
Most days =< 0 Deg. F	-	-
Most days precipitation>=0.01 in	12	1970
Most days precipitation>=0.1 in	5	many
Least November precipitation	0	1984

TABLE 2-47. SITE Weather Extremes for December (1964-1977, 1984-1993).

	TEMPERATURE (DEG F)								MAXIMUM PRECIPITATION	
	Maximum				Minimum				Water Equivalent (in.)	
Day	High	Year	Low	Year	High	Year	Low	Year	High	Year
1	65	1973	19	1991	40	1972	9	1991	0.25	1972
2	60	1975	29	1990	49	1975	11	1991	0.88	1990
3	63	1975	18	1972	48	1965	9	1972	0.30	1974
4	72	1965	18	1992	53	1987	0	1972	0.32	1971
5	68	1965	13	1972	45	1987	8	1972	0.30	1968
6	64	1970	17	1972	50	1991	10	1992	0.03	1966
7	65	1970	18	1972	52	1984	-6	1972	0.03	1965
8	64	1970	16	1972	45	1984	-8	1972	0.11	1989
9	60	1975	20	1972	49	1975	-6	1972	0.89	1989
10	63	1975	12	1972	49	1990	-7	1972	0.40	1973
11	64	1968	22	1972	51	1990	-8	1972	0.60	1989
12	54	1993	21	1967	36	1993	3	1972	0.75	1973
13	61	1976	13	1967	41	1966	5	1967	0.48	1988
14	57	1970	18	1987	39	1976	3	1967	0.25	1972
15	61	1969	19	1965	42	1969	3	1989	0.35	1966
16	63	1976	21	1989	45	1976	-3	1964	0.35	1987
17	61	1969	12	1964	44	1976	-8	1964	0.20	1971
18	61	1976	13	1989	43	1976	-4	1964	0.50	1971
19	62	1966	25	1973	38	1966	-8	1990	1.00	1971
20	62	1966	-8	1990	46	1969	-20	1990	0.76	1976
21	61	1969	-17	1990	41	1973	-24	1990	0.67	1965
22	68	1964	-1	1990	50	1964	-23	1990	0.83	1970
23	69	1964	15	1990	45	1964	-9	1990	0.57	1970
24	57	1972	15	1987	42	1964	0	1974	0.25	1965
25	60	1971	15	1987	40	1971	4	1987	0.70	1970
26	61	1976	20	1987	43	1976	10	1987	0.65	1970
27	60	1972	13	1966	37	1984	0	1966	1.81	1976
28	60	1965	20	1969	45	1984	-3	1990	0.57	1966
29	62	1965	-5	1990	44	1976	-15	1990	0.80	1973
30	56	1965	18	1967	38	1986	-3	1990	0.93	1965
31	56	1970	26	1976	43	1970	0	1967	0.17	1991
Month	50.0	1976	34.4	1990	30.9	1975	16.5	1967	1.45	1973

Average Temperature (1964-1993) Max. 39.7 Min. 25.8 Mean 33.4 Deg. F

Temperatures	*Deg. F*	*Year*
Warmest December	39.7	1976
Coldest December	25.8	1990
Most days=<32 Deg. F	23	1967
Fewest days=<32 Deg. F	6	1975
Most days =< 0 Deg. F	4	1990
Most days precipitation>=0.01 in	7	1964,1967
Most days precipitation>=0.1 in	6	1967
Least December precipitation	0.02	1990

SITE4.XLS-tablee-ss-2/9/95

2.9 STABILITY

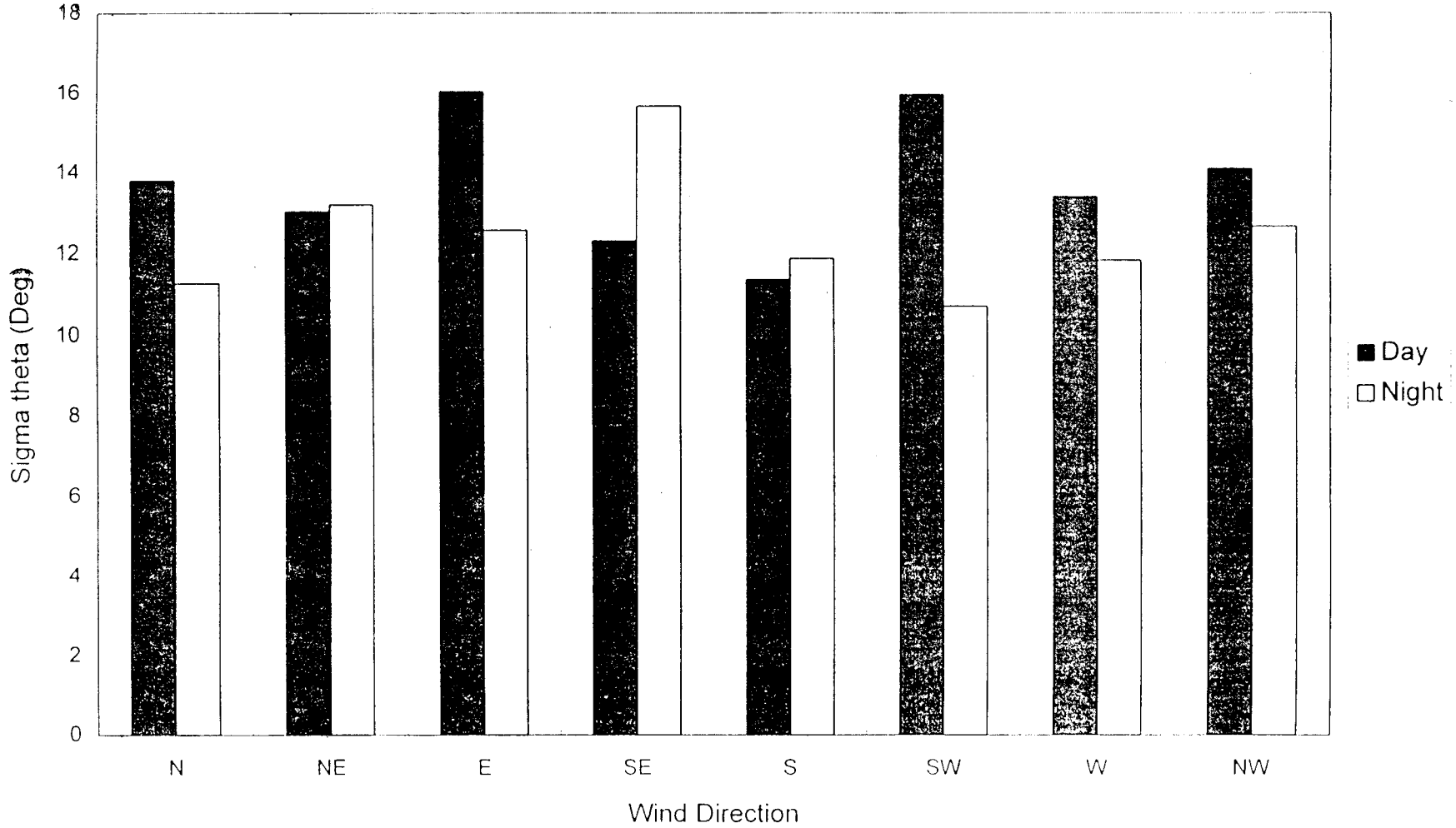
2.9.1 Stability Categories by Wind Direction

Figures 2.39 through 2.41 were based on the 1984-1993 data set only. Hourly wind data were not available before 1984.

The standard deviations of the horizontal wind direction (σ_θ) and vertical wind direction (σ_ϕ) are widely used indicators of horizontal and vertical turbulence components. Atmospheric diffusivity is proportional to σ_θ and σ_ϕ.

Charts showing Richardson Number (Ri) and Bulk Richardson Number (Rib) versus wind direction were not prepared. Wind data, with the exception of the data collected in 1992 and 1993, were poor quality and could not be used to calculate Ri and Rib. Ri and Rib versus wind direction analyses, based on the 1992 and 1993 data, have already been prepared as part of a research paper entitled, "Comparison and Evaluation of Turbulence Estimation Schemes at Rocky Flats Plant" (Bowen, 1994).

FIGURE 2.39. Horizontal Wind Direction Standard Deviation At the 10 Meter level (1989-1993).



SIE2.XLS chart-III 1/30/95

FIGURE 2-40. Vertical Wind Direction Standard Deviation at 10 Meter Level (1984-1993).

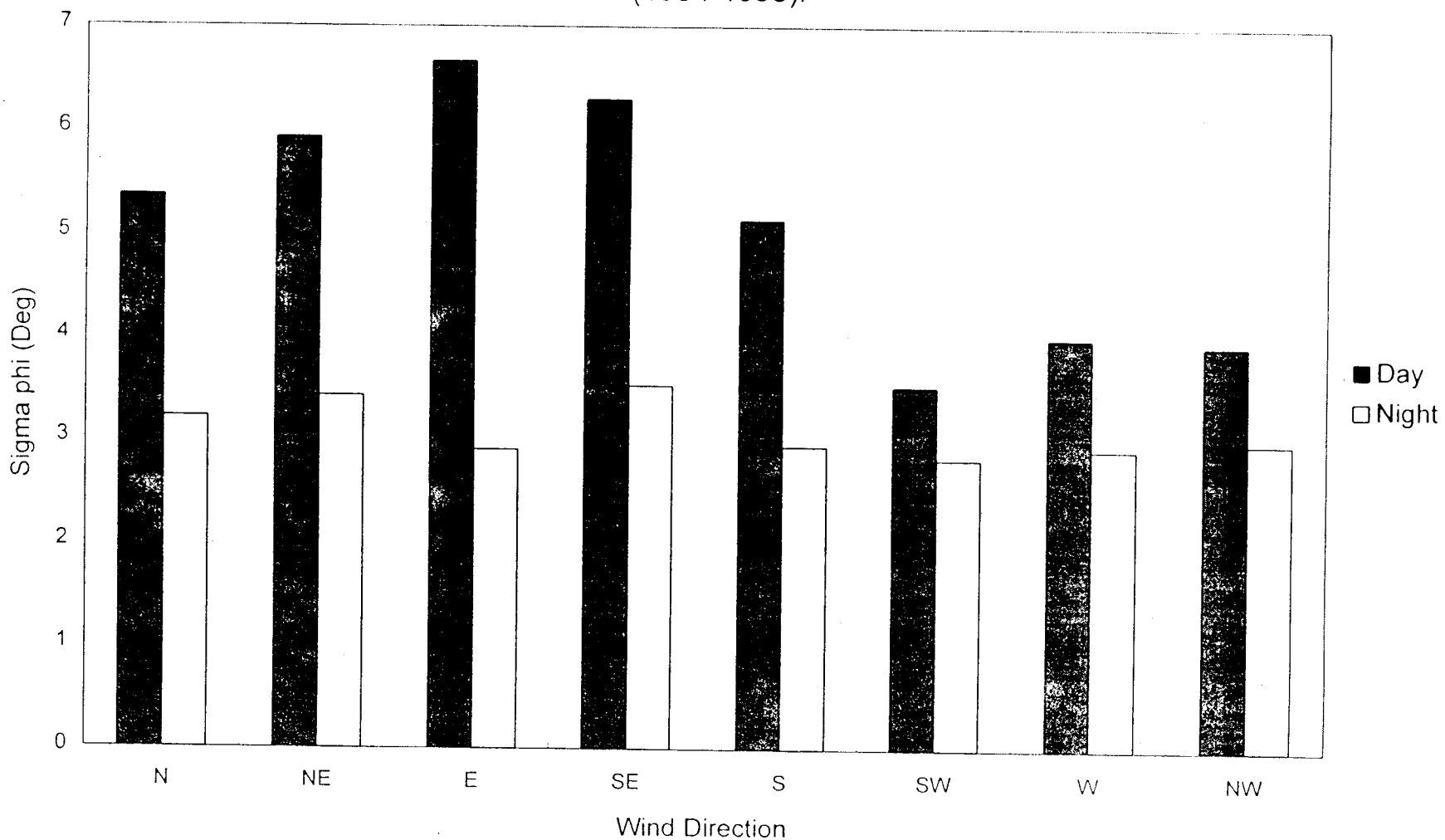
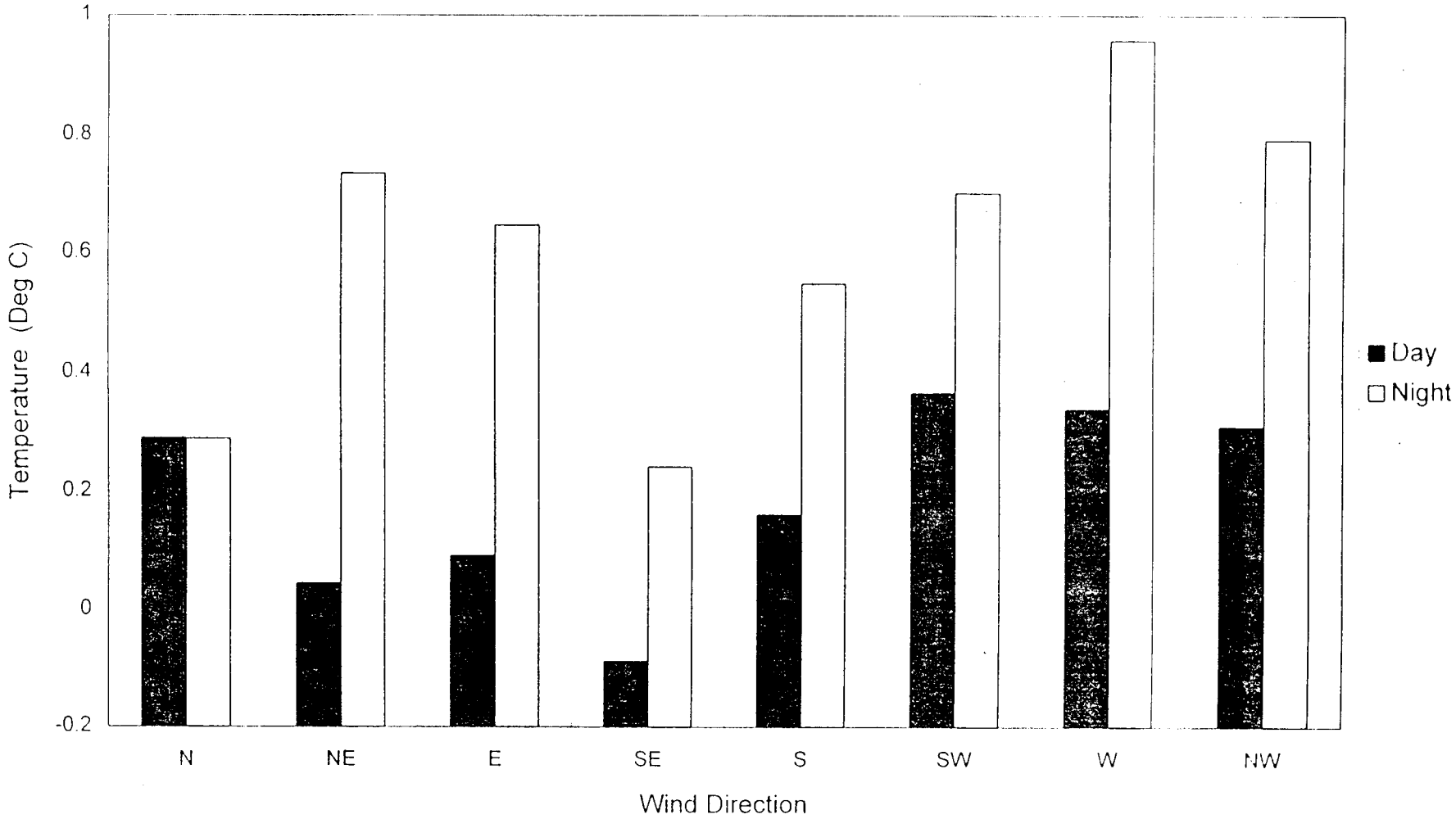


FIGURE 2.41. Temperature Differences Between 10 m and 25 m Levels (1984-1993).

(Temperature at 25 m - Temperature at 10 m)



SIEB.XLS Chart1 5 1/27/95

2.9.2 Profiles of Stability Indicators

Figures 2.42 through 2.45 were based on the 1984-1993 data set only. Hourly wind data were not available before 1984.

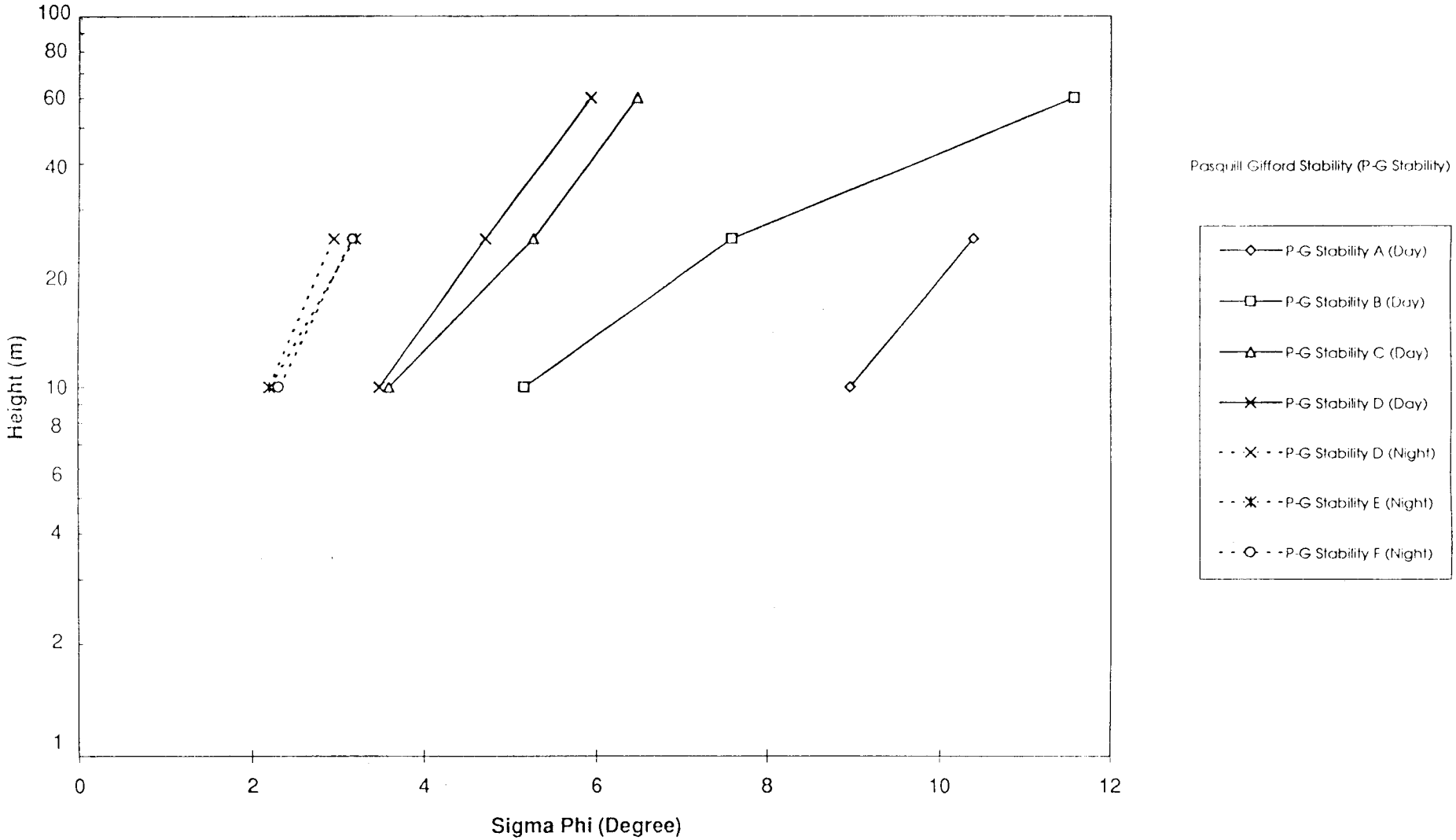
The Objective Turner Method (OTM) was used to determine the Pasquill-Gifford (P-G) stability categories. P-G stability categories are as follows: A (very unstable), B (moderately unstable), C (slightly unstable), D (neutral), E (moderately stable) and F (very stable). These categories were assigned to each hour of data using the following criteria:

	Day Insolation (W/m^2)			Night	
Avg WS at 10 m (m/s)	>=700 (strong)	350-700 (moderate)	70-350 (slight)	Negative delta T	Positive delta T
<2	A	A	B	E	F
2-3	A	B	C	E	F
3-5	B	B	C	D	E
5-6	C	C	D	D	D
>6	C	D	D	D	D

Nighttime profiles do not have values at the 60-meter level due to the method of calculating stability categories using OTM. In place of insolation (measurements used for the daytime stability categories) delta temperature is used. The absence of temperature measurements above the 60-meter level precludes calculating stability categories at the 60-meter level.

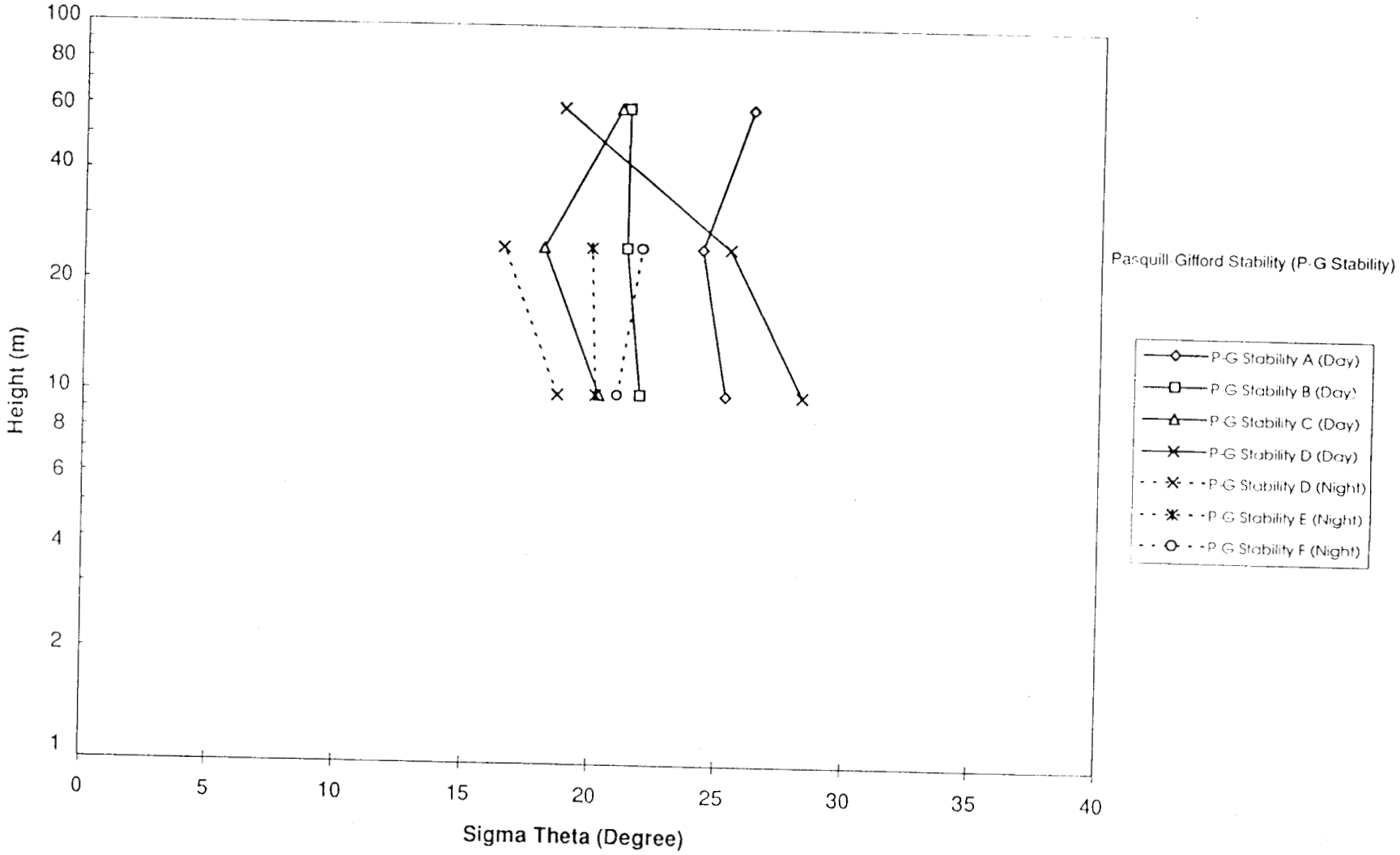
Charts showing vertical profiles of Richardson Number (Ri) and Bulk Richardson Number (Rib) were not prepared. Wind data, with the exception of the data collected in 1992 and 1993, were poor quality and could not be used to calculate Ri and Rib. Ri and Rib vertical profiles based on the 1992 and 1993 data have already been prepared as part of a research paper entitled, "Comparison and Evaluation of Turbulence Estimation Schemes at Rocky Flats Plant" (Bowen, 1994).

FIGURE 2.42. Vertical Profiles of Sigma Phi (1984-1993).



SITE2.XLS-Chart-out1-2/10/95

FIGURE 2.43. Vertical Profiles of Sigma Theta (1984-1993).



SITE2.XLS-Chart-uu2-2/10/95

FIGURE 2.44. Vertical Profiles of Wind Speed (1984-1993).

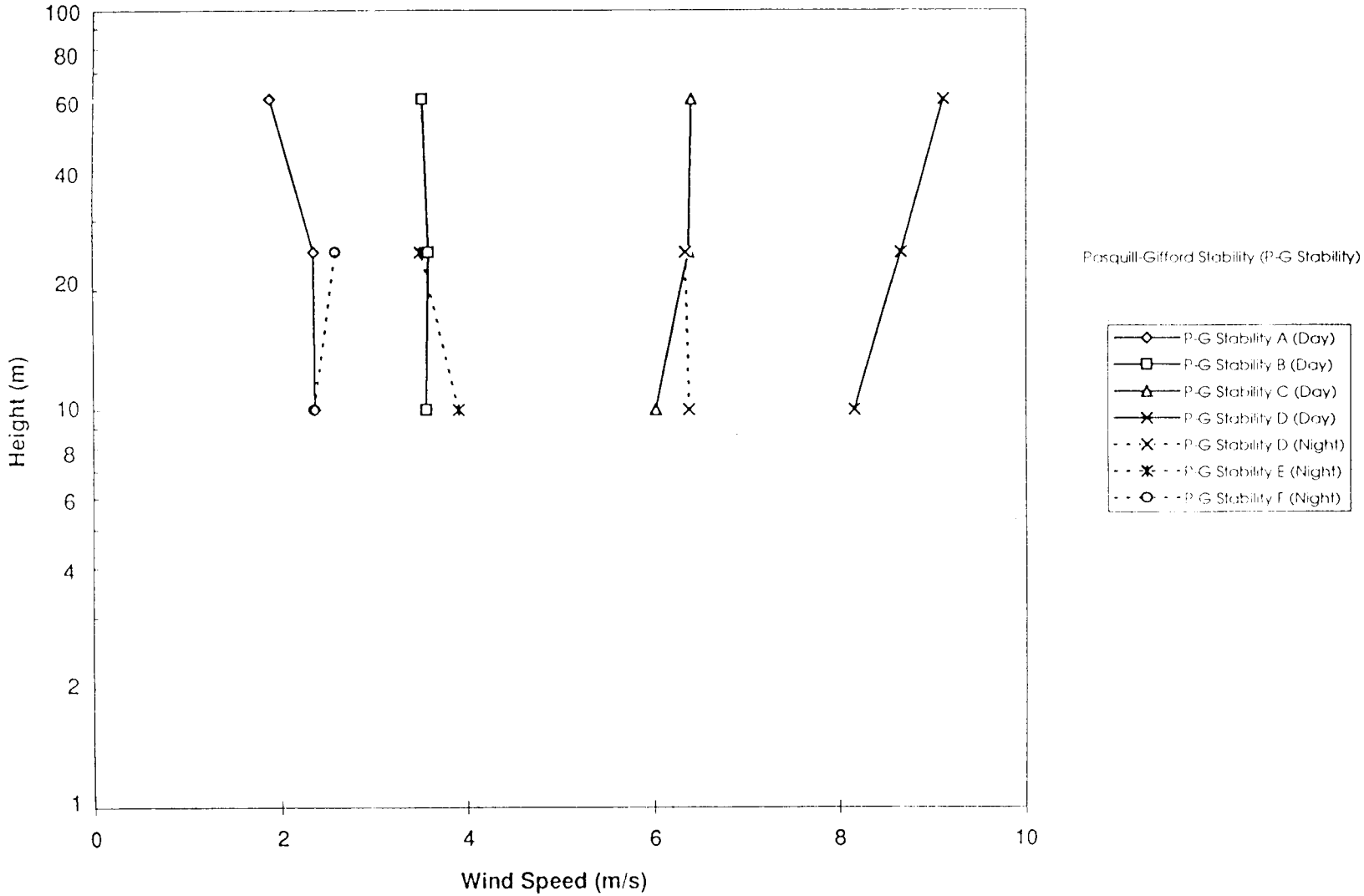
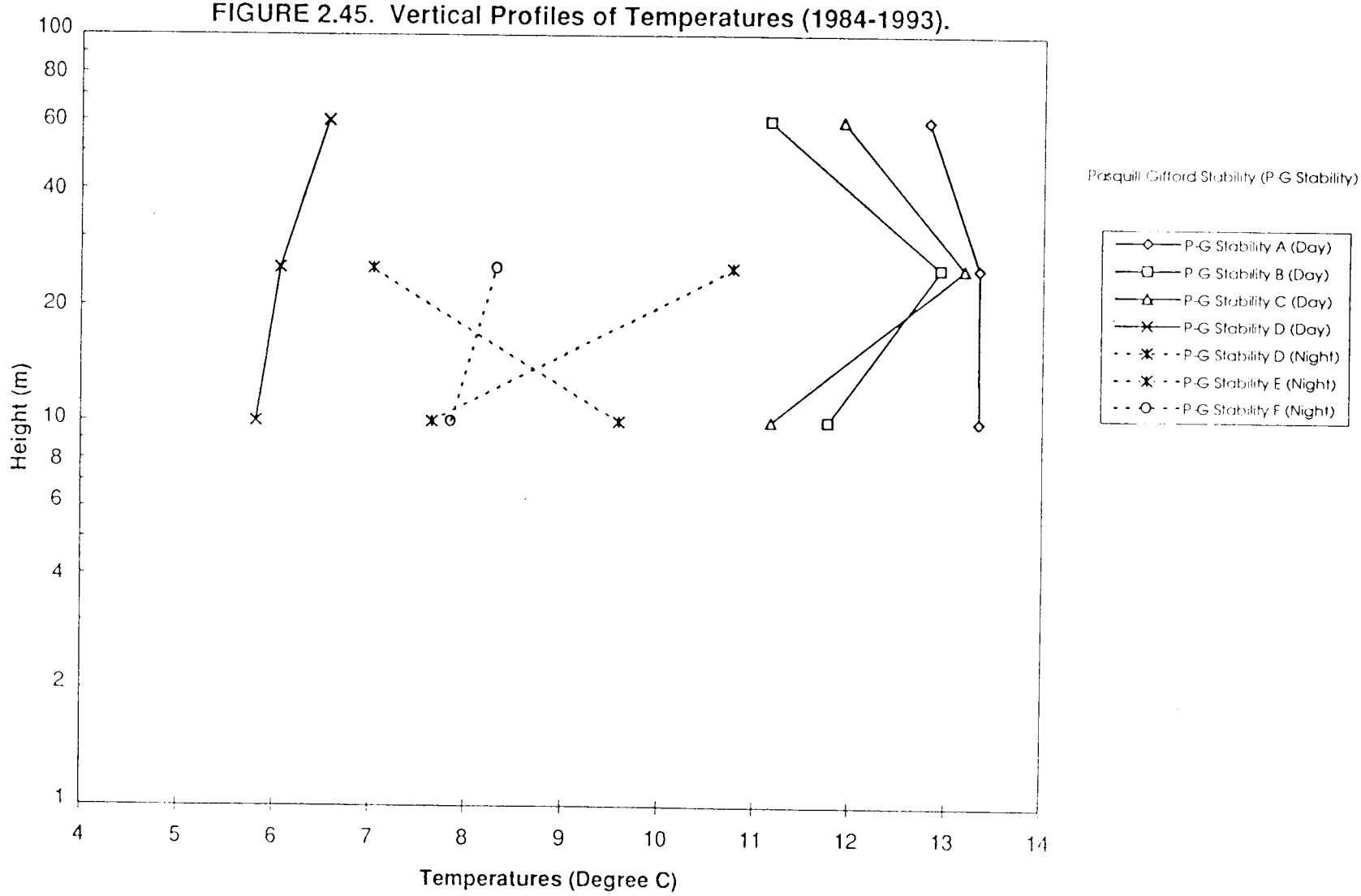


FIGURE 2.45. Vertical Profiles of Temperatures (1984-1993).



SITE2 XLS-Chart-uu4-2/10/95

2.9.3 Aerodynamic Roughness

Table 2.48 compares aerodynamic roughness length (Zo) determined graphically and using the EPA-preferred method by eight wind directions. The graphical method used logarithmic plots of the average wind speed at the three levels (10, 25 and 61 meters) for each of the eight specified wind directions collected at the West Buffer Zone location. The zero intercept of these plots determined the values of Zo. The EPA-preferred (EPA, 1987) method determines Zo using the following equation:

$$Z_o = \left(\frac{e\left(\frac{u}{\sigma u}\right)}{Z} \right)$$

The 1984-1993 data set only was used in this analysis. Wind data collected at multiple levels were not available before 1984.

The results of the graphical method gave Z_o values that were very small. These smaller-than-expected values are due to small changes in the average wind speeds with height. The EPA preferred method, on the other hand, gave results in the range from approximately 30 centimeters at the 60-meter level for two wind sectors to hundredths of a centimeter for two wind sectors at the 10-meter level.

TABLE 2-48. Aerodynamic Roughness Length by Eight Wind Directions (1984-1993).

	Graphical Method Roughness Length (m) 10-60 meters	EPA Preferred Method Roughness Length (m) 10 m	25 m	60 m
N	9.42E-10	6.15E-04	1.90E-03	1.99E-02
NE	1.19E-15	5.25E-04	5.65E-02	9.92E-02
E	4.28E-07	4.45E-03	1.26E-03	5.84E-03
SE	1.87E-11	8.43E-03	3.01E-02	1.76E-01
S	1.42E-09	1.10E-03	2.81E-03	1.74E-02
SW	2.81E-03	1.63E-02	7.79E-02	3.13E-01
W	6.91E-04	4.80E-02	1.11E-01	2.86E-01
NW	5.33E-06	4.89E-02	1.06E-01	3.01E-01

Calculations based on Wind Speed >=5 m/s and Stability ="D"

2.9.4 Dispersion

Figures 2.46 and 2.47 were based on the 1984-1993 data set only. Hourly wind data were not available before 1984 at the Site. The curves of sigma-y and sigma-z in terms of downwind distance were calculated using the following equations (Draxler, 1976):

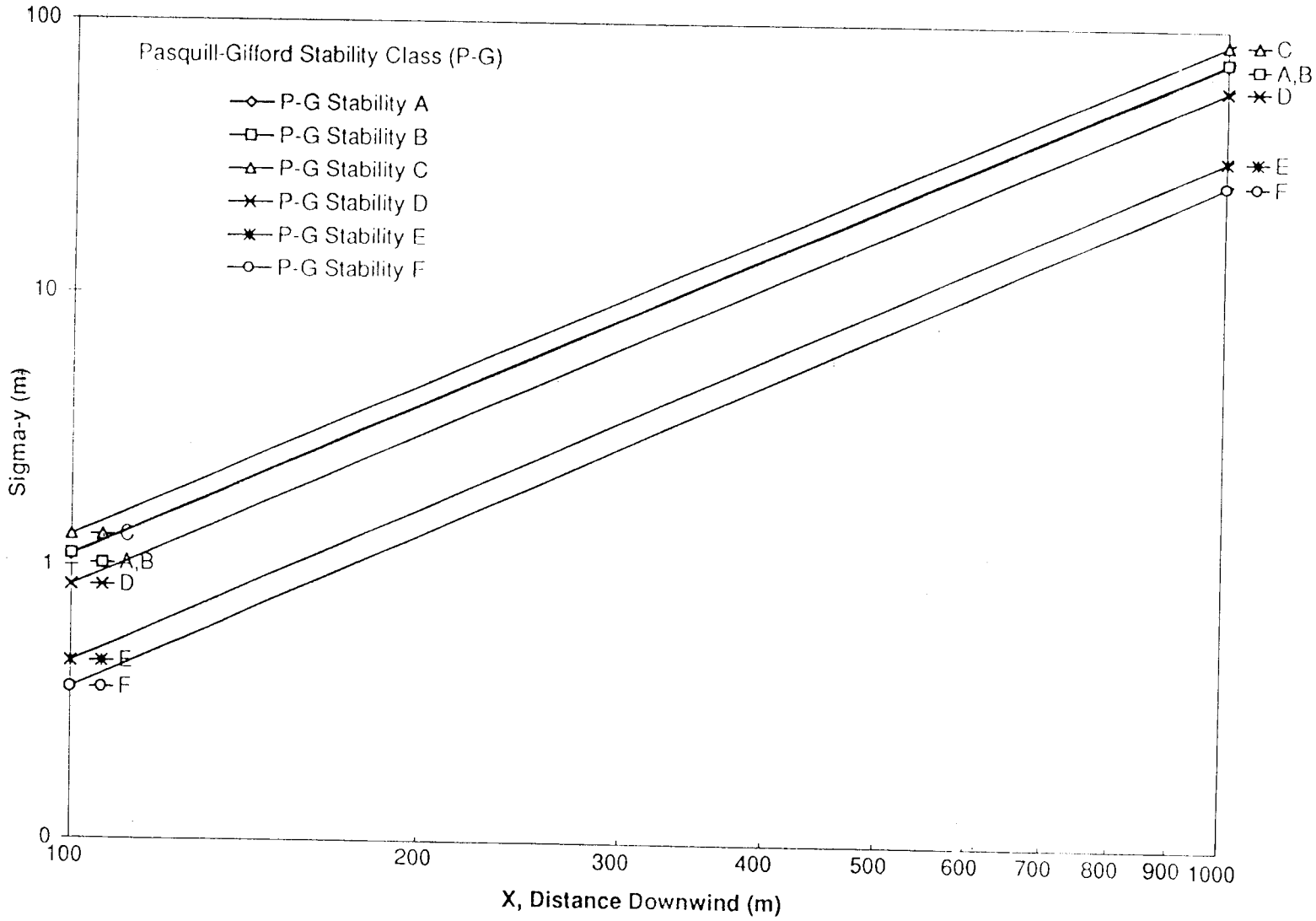
$$\text{Sigma-y} = \text{sigma-theta} \cdot X \cdot fy \cdot (T / Tiy)$$

$$\text{Sigma-z} = \text{sigma-w} * (X / AU) * fz * (T / Tiz)$$

Where:

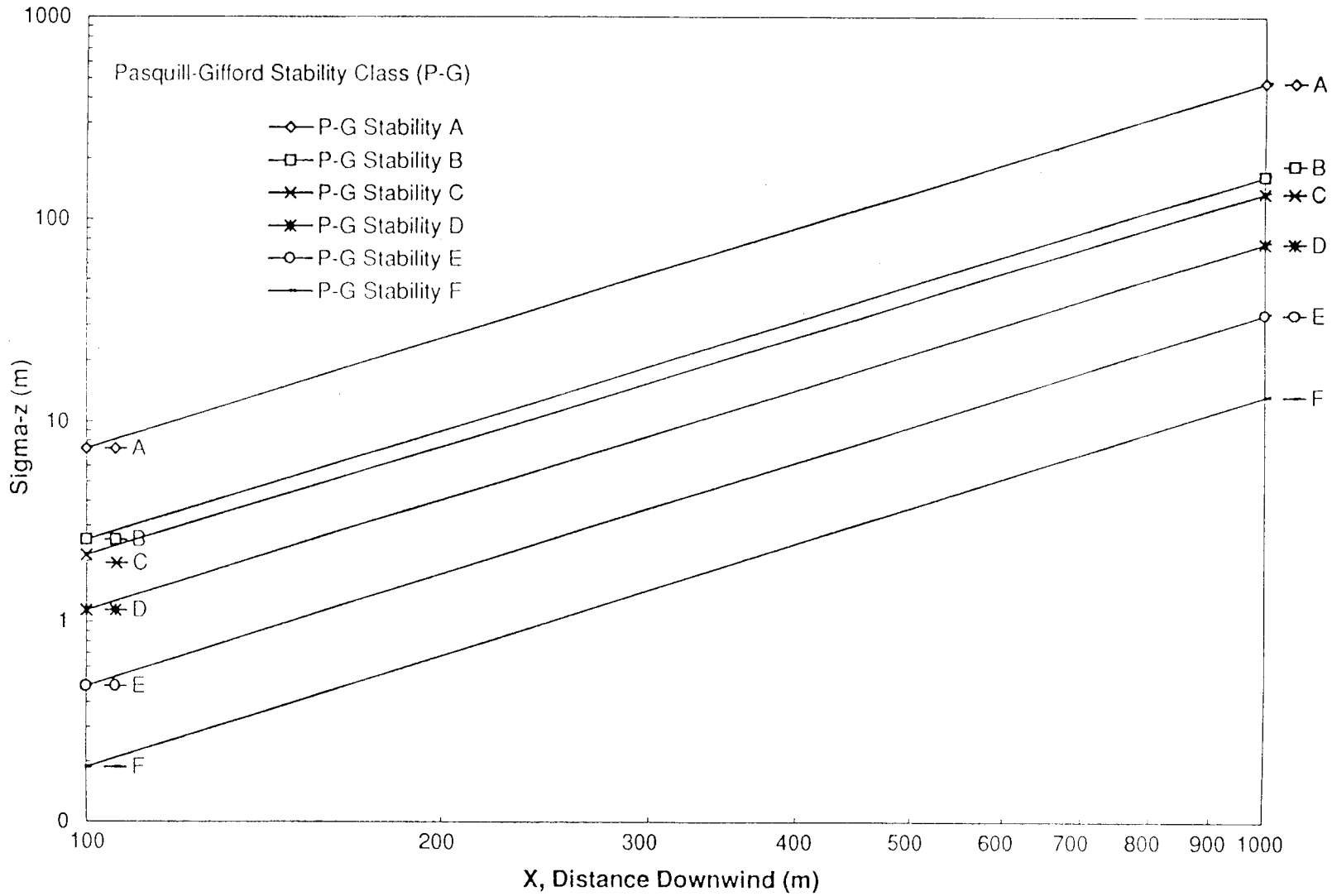
sigma-theta	=	standard deviation of the horizontal wind direction (rad)
sigma-w	=	standard deviation of the vertical wind speed (m/s)
X	=	downwind distance (m)
AU	=	average wind speed (m/s)
fy	=	1 / (1 + 0.9 * (T / Tiy)^0.5)
fz	=	1 / (1 + 0.9 • (T / Tiz)^0.5)
T	=	X/U (sec)
Tiy	=	500 constant, dependent on stability
Tiz	=	300 constant, dependent on stability

FIGURE 2.46. Calculated Horizontal Dispersion Coefficients (Sigma-y) (1984-1993).



SITE2 XLS-Chart-WW1-2/10/95

FIGURE 2-47. Calculated Vertical Dispersion Coefficients (Sigma-z) (1984-1993).



SITE2.XLS-Chart-WW2-2/10/95

2.9.5 Comparison of Stability Class Methods

Tables 2.49 and 2.50 were based on the 1984-1993 data only. Hourly wind data were not available before 1984. The sigma-phi versus sigma-theta comparisons do not show good correlation. Due to the lee effects of the Rocky Mountains, sigma-phi is not a good indicator of stability.

TABLE 2.49. Probability of Occurrence of Sigma-Phi Derived Stability Versus Objective Turner Method Derived Stability Categories at SITE (1984-1993).

SUMMER

	Sigma Phi (%)						Totals
	A	B	C	D	E	F	(%)
OTM							
A	0.06	0.06	0.65	3.49	4.66	0.45	9.38
B	0.13	0.06	0.58	8.93	17.14	3.49	30.34
C	0.00	0.06	0.19	0.84	3.49	4.66	9.25
D	0.00	0.00	0.00	0.26	1.36	10.35	11.97
E	0.00	0.00	0.00	0.06	7.63	19.79	27.49
F	0.00	0.00	0.00	0.00	5.50	6.08	11.58
Totals	0.19	0.19	1.42	13.58	39.78	44.83	100.00

WINTER

	Sigma Phi (%)						Totals
	A	B	C	D	E	F	(%)
OTM							
A	0.00	0.00	0.06	0.91	1.64	0.23	2.83
B	0.00	0.00	0.00	2.66	11.85	5.61	20.12
C	0.00	0.00	0.00	0.23	5.27	4.48	9.98
D	0.00	0.06	0.06	0.74	18.88	17.40	37.13
E	0.00	0.00	0.06	0.40	9.01	9.58	19.05
F	0.00	0.00	0.00	0.34	5.16	5.39	10.88
Totals	0.00	0.06	0.17	5.27	51.81	42.69	100.00

TABLE 2.50. Probability of Occurrence of Sigma-Theta Derived Stability Categories Versus Objective Turner Method Derived Stability at SITE (1984-1993).

SUMMER

	Sigma Theta (%)						Totals
	A	B	C	D	E	F	(%)
OTM							
A	5.96	4.38	2.36	0.22	0.00	0.00	12.92
B	14.49	11.57	4.72	1.12	0.11	0.11	32.13
C	1.57	1.91	0.56	0.56	0.00	0.00	4.61
D	0.11	0.67	0.34	0.56	0.22	0.00	1.91
E	2.81	7.08	8.54	10.00	2.02	0.11	30.56
F	2.47	2.58	5.84	5.06	1.91	0.00	17.87
Totals	27.42	28.20	22.36	17.53	4.27	0.22	100.00

WINTER

	Sigma Theta (%)						Totals
	A	B	C	D	E	F	(%)
OTM							
A	1.61	1.42	0.57	0.76	0.09	0.00	4.44
B	5.58	6.99	5.20	3.97	1.61	0.09	23.44
C	1.32	1.70	1.89	1.98	0.76	0.00	7.66
D	6.81	4.35	7.56	6.81	2.08	0.09	27.69
E	5.67	3.88	5.67	3.88	2.36	0.00	21.46
F	4.54	3.12	3.21	3.02	1.42	0.00	15.31
Totals	25.52	21.46	24.10	20.42	8.32	0.19	100.00

2.10 PRESSURE CONVERSION CHART

Table 2.51 presents the atmospheric pressure range normal to the Site in six unit bases.

TABLE 2-51. Atmospheric Pressure Conversion Chart

Atmospheric Pressure					
in. Hg	mbar	Kpa	mm Hg	lb/in.^2	atm
SITE					
23.50	795.83	79.58	596.90	11.54	0.79
23.52	796.51	79.65	597.41	11.55	0.79
23.54	797.19	79.72	597.92	11.56	0.79
23.56	797.87	79.79	598.42	11.57	0.79
23.58	798.54	79.85	598.93	11.58	0.79
23.60	799.22	79.92	599.44	11.59	0.79
23.62	799.90	79.99	599.95	11.60	0.79
23.64	800.58	80.06	600.46	11.61	0.79
23.66	801.25	80.13	600.96	11.62	0.79
23.68	801.93	80.19	601.47	11.63	0.79
23.70	802.61	80.26	601.98	11.64	0.79
23.72	803.29	80.33	602.49	11.65	0.79
23.74	803.96	80.40	603.00	11.66	0.79
23.76	804.64	80.46	603.50	11.67	0.79
23.78	805.32	80.53	604.01	11.68	0.79
23.80	805.99	80.60	604.52	11.69	0.80
23.82	806.67	80.67	605.03	11.70	0.80
23.84	807.35	80.73	605.54	11.71	0.80
23.86	808.03	80.80	606.04	11.72	0.80
23.88	808.70	80.87	606.55	11.73	0.80
23.90	809.38	80.94	607.06	11.74	0.80
23.92	810.06	81.01	607.57	11.75	0.80
23.94	810.74	81.07	608.08	11.76	0.80
23.96	811.41	81.14	608.58	11.77	0.80
23.98	812.09	81.21	609.09	11.78	0.80
24.00	812.77	81.28	609.60	11.79	0.80
24.02	813.44	81.34	610.11	11.79	0.80
24.04	814.12	81.41	610.62	11.80	0.80
24.06	814.80	81.48	611.12	11.81	0.80
24.08	815.48	81.55	611.63	11.82	0.80
24.10	816.15	81.62	612.14	11.83	0.81
24.12	816.83	81.68	612.65	11.84	0.81
24.14	817.51	81.75	613.16	11.85	0.81
24.16	818.19	81.82	613.66	11.86	0.81
24.18	818.86	81.89	614.17	11.87	0.81
24.20	819.54	81.95	614.68	11.88	0.81
24.22	820.22	82.02	615.19	11.89	0.81
24.24	820.90	82.09	615.70	11.90	0.81
24.26	821.57	82.16	616.20	11.91	0.81
24.28	822.25	82.22	616.71	11.92	0.81
24.30	822.93	82.29	617.22	11.93	0.81
24.32	823.60	82.36	617.73	11.94	0.81
24.34	824.28	82.43	618.24	11.95	0.81
24.36	824.96	82.50	618.74	11.96	0.81
24.38	825.64	82.56	619.25	11.97	0.81
24.40	826.31	82.63	619.76	11.98	0.82
24.42	826.99	82.70	620.27	11.99	0.82
24.44	827.67	82.77	620.78	12.00	0.82
24.46	828.35	82.83	621.28	12.01	0.82
24.48	829.02	82.90	621.79	12.02	0.82
24.50	829.70	82.97	622.30	12.03	0.82

2.11 THREE-HOUR WEATHER VARIABLES

Table 2.52 is based on the 1984-1993 data set only. Hourly data were not available before 1984.

The data presented in this manner (every third hour) made it possible to more easily compare Site data with National Weather Service data sets that are presented every third hour as well.

TABLE 2.52. Monthly Mean Three-hour Wind Speed, Wind Direction, Temperature, Dew Point, Relative Humidity, Atmospheric Pressure, and Solar Radiation (1984-1993).

Month	Hour	WS (m/s)	WD (Degree)	TEMP (Degree C)	DEWPT (Degree C)	RH (%)	PRESSURE (mb)	SOLAR RAD (w/m2)
JAN	0	5.7	274	-0.7	-12.8	43.8	809.7	3.7
JAN	3	5.2	283	-1.0	-13.1	43.3	809.5	3.3
JAN	6	5.7	280	-1.1	-13.4	43.0	809.2	2.6
JAN	9	5.4	275	-0.4	-12.7	43.0	810.0	126.7
JAN	12	5.5	322	1.5	-11.3	42.4	811.0	453.1
JAN	15	5.6	336	2.0	-11.0	41.8	809.9	296.7
JAN	18	5.4	289	0.2	-11.8	44.2	809.8	4.3
JAN	21	5.2	278	-0.5	-12.5	44.2	809.7	2.7
FEB	0	5.1	276	0.2	-10.5	49.2	810.4	4.7
FEB	3	5.0	288	-0.3	-10.9	49.4	810.0	4.4
FEB	6	5.0	288	-0.6	-11.3	49.1	809.9	4.1
FEB	9	4.7	289	0.5	-10.3	48.8	810.8	220.6
FEB	12	5.1	73	3.3	-9.2	43.9	811.7	556.2
FEB	15	5.3	23	4.0	-9.1	42.6	810.7	379.2
FEB	18	5.1	292	1.8	-9.5	47.7	810.6	15.7
FEB	21	5.1	274	0.8	-10.0	48.9	810.5	4.1
MAR	0	4.8	282	2.7	-7.7	50.2	809.6	4.8
MAR	3	4.4	286	2.0	-8.3	50.9	809.3	4.2
MAR	6	4.4	284	1.5	-8.6	50.7	809.2	5.9
MAR	9	4.5	318	3.5	-7.5	48.7	810.1	343.7
MAR	12	5.1	61	6.1	-6.8	43.5	810.7	625.8
MAR	15	5.4	20	7.4	-6.7	40.9	809.7	461.7
MAR	18	4.8	310	5.9	-6.9	44.2	809.6	44.8
MAR	21	5.0	280	3.9	-7.3	48.2	809.9	4.8
APR	0	4.4	276	6.1	-4.4	50.7	810.6	12.6
APR	3	4.3	283	5.2	-5.0	52.0	810.1	11.9
APR	6	4.3	283	4.8	-5.5	51.0	810.0	31.8
APR	9	4.7	31	7.4	-4.1	47.9	810.9	454.9
APR	12	5.1	59	10.0	-3.9	42.4	811.0	696.0
APR	15	5.4	24	11.0	-3.7	40.6	810.2	493.7
APR	18	5.0	333	10.1	-3.4	43.1	810.1	108.7
APR	21	4.6	273	7.7	-3.7	48.4	810.6	12.5
MAY	0	4.3	272	11.0	-0.8	46.7	812.6	4.1
MAY	3	3.8	277	10.0	-1.0	49.6	812.0	4.5
MAY	6	3.7	285	9.4	-0.9	51.9	812.1	66.3
MAY	9	4.1	81	12.5	0.6	46.9	813.2	529.7
MAY	12	4.6	83	15.4	0.5	39.5	813.2	736.5
MAY	15	5.5	56	16.5	0.3	36.7	812.4	514.9
MAY	18	5.0	340	15.4	0.6	39.8	811.9	143.7
MAY	21	4.7	275	12.7	0.1	45.0	812.3	6.4
JUN	0	4.2	270	15.6	3.4	46.8	814.9	4.9
JUN	3	3.8	280	14.4	2.8	48.2	814.6	4.8
JUN	6	3.5	277	14.3	2.9	49.0	814.6	87.8
JUN	9	3.5	81	17.7	4.7	45.0	815.8	560.4
JUN	12	4.0	85	20.4	4.6	38.0	815.9	747.7
JUN	15	4.6	33	21.4	4.3	35.6	815.2	511.1
JUN	18	4.3	328	20.4	4.4	37.9	814.6	192.3
JUN	21	4.2	257	17.5	4.1	43.8	814.9	8.5
JUL	0	4.0	272	18.5	5.6	45.3	817.0	3.0
JUL	3	3.6	286	17.4	5.0	47.2	816.5	3.0

TABLE 2.52. (Continued).

Month	Hour	WS (m/s)	WD (Degree)	TEMP (Degree C)	DEWPT (Degree C)	RH (%)	PRESSURE (mb)	SOLAR RAD (w/m2)
JUL	6	3.3	282	17.0	5.1	48.5	816.5	60.5
JUL	9	3.4	66	20.4	6.8	44.1	817.9	540.4
JUL	12	3.9	79	23.4	6.6	36.9	818.3	715.9
JUL	15	4.5	60	24.3	6.3	34.5	817.6	514.6
JUL	18	4.9	327	23.1	6.5	37.8	817.0	182.9
JUL	21	4.3	266	20.2	6.2	42.8	817.0	5.4
AUG	0	3.8	270	18.1	5.1	44.4	817.5	3.4
AUG	3	3.4	284	17.1	4.5	45.7	817.1	2.3
AUG	6	3.2	284	16.5	4.3	46.8	817.0	26.2
AUG	9	3.2	53	19.9	6.0	42.9	818.5	484.8
AUG	12	3.8	78	22.6	6.2	36.6	819.0	689.9
AUG	15	4.3	54	23.2	6.1	35.3	818.4	454.8
AUG	18	4.4	284	21.8	6.2	38.6	817.6	128.3
AUG	21	4.0	255	19.3	5.7	43.1	817.5	4.3
SEPT	0	3.7	270	14.3	1.1	43.2	815.8	4.7
SEPT	3	3.7	270	13.4	0.7	44.6	815.5	4.1
SEPT	6	3.4	273	12.6	0.2	45.9	815.6	12.8
SEPT	9	3.3	66	15.3	1.7	42.9	816.7	384.7
SEPT	12	4.2	87	18.2	2.1	36.7	817.2	672.0
SEPT	15	4.3	69	19.6	2.0	33.7	816.1	465.4
SEPT	18	4.0	308	18.0	2.1	37.2	815.7	71.6
SEPT	21	4.2	271	15.4	1.3	41.3	815.8	6.5
OCT	0	3.8	274	9.0	-4.9	39.8	814.4	3.8
OCT	3	3.6	287	8.1	-5.3	40.7	814.0	3.3
OCT	6	3.5	274	7.6	-5.5	41.8	813.9	3.6
OCT	9	3.4	99	9.5	-4.4	40.6	815.0	277.9
OCT	12	4.1	92	12.1	-3.6	35.9	815.4	559.5
OCT	15	4.4	48	13.5	-3.5	33.4	814.5	372.6
OCT	18	3.7	292	11.6	-3.8	36.5	814.2	21.8
OCT	21	4.0	272	9.7	-4.6	39.1	814.4	3.6
NOV	0	4.7	274	3.5	-8.9	42.4	810.6	7.8
NOV	3	4.8	273	2.9	-9.4	42.5	810.3	5.7
NOV	6	4.7	265	2.8	-9.9	41.8	810.3	6.1
NOV	9	4.5	253	3.7	-9.1	41.7	811.2	205.2
NOV	12	4.9	93	5.9	-8.0	38.4	811.7	487.5
NOV	15	5.2	348	6.6	-7.9	36.7	810.8	267.7
NOV	18	4.6	270	4.6	-8.5	40.4	810.7	6.7
NOV	21	4.9	268	3.8	-8.8	41.5	810.7	5.2
DEC	0	4.6	274	-0.4	-12.6	44.5	809.6	4.8
DEC	3	4.5	279	-0.9	-13.0	45.4	809.4	4.8
DEC	6	5.1	282	-1.0	-13.2	44.9	809.2	5.4
DEC	9	5.0	283	-0.3	-12.8	44.4	810.1	147.9
DEC	12	5.2	286	1.6	-11.3	43.4	810.8	417.5
DEC	15	5.2	306	2.2	-11.1	42.2	809.8	236.6
DEC	18	4.7	284	0.3	-12.0	44.6	809.7	4.8
DEC	21	4.6	277	-0.2	-12.6	44.0	809.7	4.5

GLOSSARY

absolute humidity	Ratio of Atmospheric water vapor mass to moist atmospheric mass (g/kg).
absolute temperature	Temperature scale based on absolute zero, given in degrees kelvin (K= °C + 273).
Adiabatic process	Expansional cooling or compressional warming of air parcels in which there is no net heat exchange between the air parcels and the surrounding air.
air density	Mass per unit volume of air, about 0.96 kg/m^3 at the Site and 1.29 kg/m^3 at sea level.
anemometer	Instrument used to measure wind speed.
aneroid barometer	A portable instrument that uses a flexible metal chamber and spring to measure atmospheric pressure.
apparent temperature	A calculated air temperature at which the heat loss form exposed skin accounts for the wind-speed and humidity effects at the actual temperature. Warming effects by sunshine is often included.
atmospheric pressure	The force per unit area exerted on any surface by air molecules.
atmospheric stability	Property of an air layer encouraging or discouraging buoyancy to air parcels moving vertically in the air layer; depends on the temperature profile of the air layer.
autumn	Season between autumnal equinox and the winter solstice, about September 21 to December 21; meteorologically, by convention, September through November.
barometer	An instrument used to measure atmospheric pressure. See aneroid barometer and mercurial barometer.
climate	Weather variations of some locality averaged over some time period, plus extremes in weather behavior observed during the same period.
climate normal	Mean weather, plus weather variations, at some locality for some period, usually 30 years. Normal is sometimes defined as the mean +/- 2 standard deviations for variables such as temperature, precipitation and snowfall. Abnormal weather represents extremes > 2 standard deviations from the mean.

condensation	Process by which water changes phase from a vapor to a liquid.
convection	Vertical air motion in which warm air rises and cold air sinks.
convergence	A wind pattern whereby there is a net inflow of air over some region.
cooling-degree day	Unit that measures the need for air conditioning when the average daily air temperature [(maximum + minimum)/2] exceeds a specific base, commonly 65°F or 70°F; computed by subtracting the base from the average daily temperature (°F).
design	A value, such as a specific temperature, that occurs with a specific frequency during the year. A 1% winter design temperature, for example, can assist in designing a heating system and determining insulation requirements for a building.
dew point or dew-point temperature	Temperature to which air must be cooled at constant pressure to reach saturation.
diffuse insolation	Solar radiation that is scattered or reflected by the atmosphere or its components (clouds, for example) to the earth's surface.
direct insolation	Solar radiation that is transmitted directly through the atmosphere to the earth's surface without interacting with the atmosphere or its components.
dispersion	The horizontal and vertical spreading of air pollution by atmospheric turbulent motions, resulting in lower concentrations.
divergence	A wind pattern whereby there is a net outflow of air over some region.
dry adiabatic cooling (warming)	Expansion (compressional) cooling (warming) of rising (sinking) unsaturated air parcels. No heat exchange occurs between the air parcels and the surrounding air.
dry adiabatic lapse rate	Rising (sinking) unsaturated air parcels cools (warm) at the rate of about 5.5°F per 1000 ft, or 10°C per 1000 m of rise (fall).
dry-bulb temperature	The actual air temperature as measured by a dry-bulb thermometer.

equinoxes	The first day of spring (~March 21) and autumn (~September 21) when the sun is directly over the equator. Day and night are of equal length at equinox.
evaporation	The change of water phase form liquid to vapor at a temperature below the boiling point of water.
evapotranspiration	Vaporization of water through direct evaporation from wet surfaces and the release of water vapor by vegetation.
expansional cooling	A temperature drop associated with a pressure decrease of volume of air, as when air rises within the atmosphere.
extreme value analysis	Plot of annual variable extremes, such as temperature and precipitation, used to estimate expected values such as 50- and 100-year return periods.
fog	A cloud in contact with the earth's surface that reduces visibility to less than 1.0 km (0.6 miles).
freeze	A day in which the minimum temperature is 32°F or below. A hard freeze is a day in which the temperature dips to 28°F or below.
freeze-thaw day	Day in which the maximum temperature exceeds 32°F and the minimum is 32°F or less.
friction layer	Atmospheric layer extending from the ground surface to 1-2 km above, where winds are affected by ground frictional resistance; boundary layer.
frost	Ice crystals formed by water vapor deposition on a surface at temperatures of 32°F or below.
frost point	Temperature to which air must be cooled (if at 32°F or below at constant pressure to reach saturation.
gas law	Relationship among the variables of state. Pressure is proportional to the product of temperature and density.
Gaussian dispersion model	An atmospheric dispersion model that estimates down wind pollutant concentrations, given vertical and horizontal distances of and from the pollutant cloud. Pollutant drop-off is assumed to follow a normal distribution from the cloud center line.

gradient	The change in some variable (such pressure or temperature) with distance.
gravity	The force that holds all objects onto the earth and that accelerates them toward the earth's surface. Gravity results from the net effect of gravitational and centrifugal force caused by the earth's rotation.
growing-degree day	Same as cooling-degree day (see), except that the growing-degree day is used to measure the growth potential of plants. Common bases are 40°F through 70°F.
gust	A quick, sharp and brief increase in wind speed.
heat	The total molecular energy contained by a give amount of substance.
heating-degree day	Unit that measures the need for space heating when the average daily air temperature [(maximum + minimum)/2] is less than a specific base, usually 65°F. The measurement is computed by subtracting the average daily temperature from the base.
insolation	Incoming solar radiation. See diffuse insolation and direct insolation.
langley (ly)	An energy flux unit defined as 1 calorie/cm^2 or 1.4 kW/m^2.
lapse rate	Change of temperature with height.
latent heat transfer	Movement of heat from one place (moist soil, for example) to another (the atmosphere) as a consequence of the water phase changes. Heat is required for evaporation and sublimation at the earth's surface. It is released in the form of condensation and deposition within the atmosphere.
mercurial barometer	A mercury-filled tube used to measure air pressure; a high-accuracy barometric standard.
meteorology	Scientific study of the atmosphere and atmospheric processes.
microclimate	Means and extremes in weather over a very small spatial scale (usually on the order of centimeters to meters).
microscale weather	The smallest scale of weather (<1 km).
millibar (mbar)	A conventional meteorological unit of air pressure. The standard sea-level air pressure is 1013.25 mbar.

mixing layer	Surface layer of the atmosphere in which air is thoroughly mixed by convection. Mixing depth is the thickness of the mixing layer, which often coincides with the boundary layer.
mixing ratio	Mass of water vapor per mass of dry air; expressed as grams per kilogram (g/kg).
moist adiabatic lapse rate	A variable cooling rate of rising saturated air parcels. This rate is less than the dry adiabatic lapse rate because some of the cooling is offset by the latent heat release from condensation.
neutral atmosphere	An atmosphere that has a lapse rate nearly identical to the dry adiabatic lapse rate, implying no tendency for a displaced air parcel to gain or lose buoyancy; represented by the D stability category.
normal	See climate normal.
orographic lifting	Rising motion of air forced by topography.
orographic precipitation	Rainfall or snowfall from clouds forced by topographic air uplift.
Pasquill-Gifford stability categories and curves	Stability categories, designated A through F, which characterize stability of lower atmosphere, with A most unstable, D neutral and F most stable. Horizontal (sigma y) and vertical (sigma z) dispersion values have been calculated by stability category and downwind distance, assuming a smooth surface.
precipitation	Water in solid or liquid form that falls to the earth's surface from clouds. Water-equivalent precipitation is a measure of rain and melted snow or ice.
psychrometer	An instrument used to determine relative humidity, dew point and dry- and wet bulb temperatures.
pyranometer	An instrument that measures total insolation (direct and diffuse) received on an area parallel to the ground.
radiation	Energy transported via electromagnetic waves traveling at the speed of light and capable of traveling through a vacuum.
radiation fog	Fog formed by the nighttime radiational cooling of a humid air layer so that its relative humidity approaches 100%.

radiation temperature inversion	Cooling of a surface layer by outgoing infrared radiation, resulting in the coldest air at the surface and air temperatures increasing with altitude.
rain	Precipitation consisting of liquid water droplets having diameters between 0.02 in. (0.5 mm) and 0.2 in. (5.0 mm).
rain gauge	A device, usually a cylindrical container, that measures precipitation (rain).
reduction to sea level	An adjustment applied to surface air-pressure readings to eliminate the influence of station elevation.
relative humidity	Percentage of water vapor that air can hold at a specific temperature.
return period (Tr)	Expected time period between occurrences of a specific event (i.e., 100-year return period of a specific daily snowfall).
saturation mixing ratio	The maximum concentration of water vapor in a given volume of air at a specific temperature.
saturation vapor pressure	The maximum possible vapor pressure in a sample of air at a specific temperature.
snow	Precipitation consisting of aggregation of ice crystals in the form of hexagonal flakes.
solar altitude	The angle of the sun above the horizon.
solar constant	The flux of solar radiational energy falling on a surface at the top of the atmosphere, oriented perpendicular to the solar beam when the earth is at an average distance from the sun, about 2.00 langley/min.
solstice	Time when the sun is at its maximum poleward location relative to the earth (latitudes 23.5° north and south); first days of summer and winter.
soundings	Continuous altitude measurements that provide profiles of variables such as temperature, humidity and wind speed.
specific humidity	Ratio of atmospheric water vapor mass to the dry atmospheric mass holding it; approximately equal to absolute humidity (g/kg).

spring	Season between spring equinox and summer solstice, about March 21 through June 21; meteorologically, by convention, March through May.
stability category	See Pasquill-Gifford stability category and curves
Stable atmosphere	An atmosphere in which the temperature decreases more gradually than does the dry adiabatic lapse rate (5.5°F/1000 ft [1°C/1000m]) or actually increases with height; air parcel that resists vertical motion in stable atmosphere; represented by the E category for slightly stable and the F category for very stable.
standard atmosphere	A theoretical average atmosphere of the variables pressure, temperature and density.
sub adiabatic	Same as stable atmosphere.
summer	Season between summer solstice and autumn equinox, about June 21 through September 21; meteorologically, by convention, June through August.
super adiabatic	Same as unstable atmosphere.
supersaturation	An air sample having a relative humidity greater than 100%.
surface layer	Lowest part of the atmosphere (50 to 200 m above ground level [AGL]) that has the sharpest variations of weather variables (temperature, humidity and winds) with height.
temperature	A measure of the relative molecular activity of a substance.
temperature gradient	Temperature change with distance.
temperature inversion	See inversion.
thermometer	An instrument used to measure temperature.
tipping-bucket rain gauge	An instrument that accumulated rainfall, usually in increments of 0.01 in. (0.025 cm), by containers that alternately fill and empty (tip).
tropopause	Zone of transition between the troposphere below and the stratosphere above; top of the troposphere.

troposphere	Lowest thermal subdivision of the atmosphere in which air temperature normally drops with altitude; layer where most weather occurs.
turbidity	Dustiness of the atmosphere.
turbulence	Random, chaotic air motions that occur in scales from inches to thousands of feet (centimeters to kilometers).
ultraviolet radiation	Short-wave, high-energy solar radiation, much of which is absorbed by ozone in the stratosphere.
unstable atmosphere	An atmosphere in which the temperature decreases more with height than the dry adiabatic lapse rate (5.5°F/1000 ft [1° C/1000m]). An air parcel accelerates away from its original position after upward or downward displacement in an unstable atmosphere.
updraft	Upward-moving air, usually in a thunderstorm cell.
upslope fog	Ground-level cloud formed from the expansional cooling of humid air that is forced to ascend a mountain or plateau slope.
upslope wind	A flow of air that is directed up a slope; often can be a thermally driven, relatively deep local wind that forms over slopes during sunny days with light, large-scale winds (anabatic winds).
vapor pressure	The portion of the total air pressure accounted for by the water vapor in the atmosphere.
variables of state	Temperature, pressure and air density.
vertical pressure gradient	Decrease of air pressure with altitude.
virtual temperature	An adjustment made to the real air temperature to account for a reduction in air density because of the presence of water vapor.
water-equivalent precipitation	The total liquid content of precipitation, including rainfall and melted snow.
weather	The state of the atmosphere in terms of variables such as temperature, cloudiness, precipitation and sunshine.

wet-bulb temperature	The temperature to which air will cool when brought to saturation by evaporation of water; can be measured by wet-bulb thermometer; used to obtain dew point or relative humidity by comparing with temperature. The difference from dry-bulb temperature is called the wet-bulb depression.
wind	Air movement caused by horizontal pressure differences.
wind-chill-equivalent temperature	A calculated air temperature that takes into account the cooling effects (heat loss) of wind on exposed skin.
wind direction	Direction from which the wind is blowing.
wind rose	A diagram that indicates wind-direction frequencies and sometimes wind-speed categories.
wind shear	A change, sometimes abrupt, in wind speed or direction with height of horizontal distance.
wind vane	An instrument used to measure wind direction by pointing into the wind.
winter	Season between winter solstice and spring equinox, about December 21 through March 21; meteorologically, by convention, December through February.

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