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Analysis of the Fugitive Dust Problem Associated with the Surface Mining of Iowa Coal

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I. INTRODUCTION

A. Purpose of Study

The overall objective of this research for the Iowa Coal Project (ICP) was to determine air quality problems associated with the mining, handling and transportation of coal in Iowa using demonstration mine #1 as a case study. Specific objectives were to determine the impact of poor air quality on the environments of both the individual miner and other residents who live in areas affected by the mining, handling and transportation of coal, and to determine the meteorological factors which are highly conducive to poor environmental air quality in the mine itself and in other affected environments. The reason for undertaking the work is that the Iowa Coal Project was an environmentally oriented research endeavor concerning itself with the development of up-to-date mining practices in Iowa and its concern with the environmental impacts associated with all phases of the mining operation. Air quality problems associated with surface mining are common, but little had been done in researching these relationships with the meteorological environment associated with a surface mining operation.

B. Source Inventory

Fugitive dust is the dominant atmospheric pollutant created as a result of strip-mining operations, and is generated at virtually every phase of the operation if weather conditions are conducive. There will be slight increases (above ambient levels) of other air pollutants such as carbon monoxide and hydrocarbons; however the increases above ambient levels of these pollutants are likely to be relatively minor compared with increases of suspended particulates. Table 1 summarizes our qualitative judgement of the relative contribution of various activities to the total dust generated from the coal extraction process. The single worst source of dust is observed to be heavy machinery traveling at moderate-to-high speeds. Loaded trucks and earth haulers traveling on dirt or gravel surfaces are the greatest contributors to the problem of suspended particulates, followed next by the same vehicles empty. The speed, weight, duration of usage, and number of vehicles are the major factors. To treat each vehicle as a separate dust source is not necessary if the dust problem is viewed from outside the mine. Rather, the mine may more easily be considered as a continuous area source instead of many instantaneous line and point sources, especially if averaged over periods in excess of a few minutes. Attempts to monitor outside the site boundary for periods less than a few minutes will likely produce samples that are unrepresentative and (or) are too near the lower sensitivity limit of the collection/analysis equipment. The wide range of mining activity and dispersive capacity of the atmosphere create many possible air-quality conditions ranging from acceptable to violations of present air-quality standards, especially in the immediate mine site vicinity.

C. Present Air Quality Standards

The State of Iowa has elected to accept as its standards, the National Ambient Air Quality Standards as established by the National Environmental Protection Agency (NEPA). The primary standard for suspended particulates allows for an annual geometric mean of 75 micrograms per cubic meter ($\mu g/m^3$), and a maximum 24-hour concentration of 260 $\mu g/m^3$ not to be exceeded more than once per year. The secondary standard for suspended particulates allows an annual geometric mean of 60 $\mu g/m^3$, and a maximum 24-hour concentration of 150

Table 1

Surface-Mining Dust Potential During Dry Conditions.

SOURCE	NATURE/STRENGTH	AVERAGE DURATION	RELATIVE CONTRIBUTION	PRIMARY RECEPTOR
I. MATERIAL PREPARATION				
Ripping	low-level continuous line source	hours	Minor, except for:	Mining personnel
Blasting	high-level instantaneous point source	seconds	Minor, except for:	Mining personnel
II. MATERIAL HANDLING				
Loading	moderate-level instantaneous point source	seconds	Minor, except for:	Loader and trucker
Dumping-Unloading	moderate-level instantaneous point source	seconds	Minor, except for:	Dumper and trucker
Crushing	moderate-level instantaneous point source	minutes	Minor, except for:	Local Operator(s)
III. MATERIAL HAULING				
Site Transportation				
Road Dust	high-level continuous emitting point source	hours	Major	Miners & Local Resider
Shake-off	low-level intermittent line source	minutes	Minor	Miners
Commercial Transportation				
Road Dust	high-level continuous emitting point source	minutes-hours	Major	Trucker, Motorists & Adjacent Residents
Blow-off	low to moderate-level intermittent line source	minutes	Minor-Moderate	Motorists & Adjacent Residents

$\mu g/m^3$ not to be exceeded more than once a year (Iowa Department of Environmental Quality, 1974). In addition, warning, emergency and significant-harm alerts are issued when average 24-hour concentrations exceed 625, 875, and 1000 $\mu g/m^3$, respectively. The warning level indicates that additional control is necessary if meteorological conditions are expected to remain the same for a period of 12 hours. At the emergency level, the most stringent controls are necessary to insure that concentrations do not reach levels where imminent and substantial endangerment to the health of any significant portion of the population will occur, i.e., the significant-harm level (Seinfeld, 1975). The Mining Enforcement and Safety Administration (MESA) has set a maximum average concentration of 2 milligrams per cubic meter that mining personnel may be exposed to for a duration of eight hours. These are the standards that are currently enforced, but they may be subject to change (Michael Durham, Iowa Department of Environmental Quality, personel communication, April 18, 1977).

D. Regional Climatology

The average annual temperature and precipitation for the Weather Bureau Office in Des Moines, Iowa, during the period 1921-1955 were 50.2°F and 30.74 inches, while for a cooperative weather station two miles southwest of Oskaloosa the average annual temperature and precipitation for the period 1931-1950 were 50.9°F and 34.06 inches, respectively (U.S. Dept. of Comm., 1959). Overall long-term temperature differences tend to be minor between the Oskaloosa location (which should closely typify the climatology of the mine site) and the National Weather Service in Des Moines, Iowa. Although the National Weather Service office in Des Moines is slightly north of the mine site, its urban influence tends to counteract latitudinal differences. Overall long-term precipitation differences are better approximated using regional averages instead of point averages, thereby eliminating local variability. Des Moines is located in the southern part of the Central Iowa climatic region, Oskaloosa is located in the western part of the Southeast Iowa region, and both are within 20 miles of the South-Central Iowa region (Appendix D). Annual precipitation averages for the Central, South Central, and Southeast regions are 31.53, 32.12, and 33.56 inches, respectively. Total annual precipitation can vary greatly year to year, but annual averages are quite comparable, with the mine site averaging up to two inches more of annual precipitation than Des Moines. Due to the close similarity of long-term temperature and precipitation averages between Des Moines and Oskaloosa, National Weather Service data from Des Moines were judged to be representative of monthly and annual average mine-site values of temperature, precipitation and other meteorological parameters. Appendix C contains a summary of hourly meteorological observations at the Des Moines, Iowa, National Weather Service for the period January 1, 1951, through December 31, 1960, (U.S. Dept. of Comm. 1963).

II. EQUIPMENT AND MEASUREMENT PROCEDURES

Throughout the study, ICP data were obtained using air-quality and meteorological instrumentation either purchased through funding of the Iowa Coal Project or on loan from different state agencies. A brief description of each is given.

A. 24-Hour Particulate Concentrations Measurements

Large-volume air samples usually collected over 24-hour periods, were obtained using UNICO 500 HIGH-VOLUME AIR SAMPLERS on loan from the Agricultural Experiment Station at Iowa State University. Samples were collected on 8" x 10" glass-fiber filter paper, and analysis was conducted using a gravimetric technique. Flow rates were averaged from the entire sampling period and were corrected for elevation. The flow rates were calibrated approximately once every three months. Samples were standardized before initial and final filter weighing by allowing them to attain an equilibrium condition in a controlled environment of 75°F and less than 50% relative humidity. Samples were then weighed on a balance accurate to 0.0001 grams.

B. Suspended-Particulate Sizing Measurements

An ANDERSON 2000 HIGH-VOLUME PARTICLE-SIZING SAMPLER, on loan from the State Hygienic Laboratory in Iowa City, aerodynamically sized suspended particulate matter into four fractionations in the head (1.1, 2.0, 3.3, and 7.0 microns [μ]), with a submicron back-up filter. When operated at a flow rate of 20 cubic feet per minute, the five groups are 7.0μ or larger, 3.3μ to 7.0μ, 2.0μ to 3.3μ, 1.1μ to 2.0μ, and less than 1.1μ. These correspond approximately to particle sizes penetrating to the nasal canal, trachea and primary bronchi, secondary bronchi, terminal bronchi, and alveoli, respectively (Anderson 2000 Inc., 1976, Mainwaring, 1976). Sample filters were analyzed using the same procedure as for 24-hour total-particulate concentration measurements (Hunt, 1972).

C. Meteorological Measurements

Meteorological data were collected using the CLIMATRONICS ELECTRONIC WEATHER STATION (EWS) which was purchased through funding on the Iowa Coal Project. The equipment is relatively self-contained and operates on either 110 volts AC, or two standard 6-volt lantern batteries. The meteorological variables measured and their accuracies were temperature (± 1.0°F), relative hunidity (± 3%), wind speed (± 0.25 MPH, with a threshold speed of 0.75 MPH), wind direction (± 5 degrees), solar radiation (± 3%), and precipitation (± 0.01 inches). The batteries received great stress due to extremely cold weather in December 1976 and January 1977, causing the system to malfunction occasionally. The EWS operates well in above-freezing weather, but tends to fail during subzero (Fahrenheit) conditions. Between freezing and subzero conditions the EWS operation was intermittent and sporadic. To overcome this problem the instrument was modified to run off a standard automobile battery thereby increasing its reliability and economy of operation.

III. DATA COLLECTION

A. Particle Size Distribution Data

High-volume, aerodynamically-sized particle distributions were measured in seven separate experiments that were conducted during August and September 1976. Measurements were taken at three gravel-road locations (one in Story County and two in Mahaska County) to estimate order-of-magnitude concentrations of suspended particles within 100 feet of a gravel road. Experiments consisted of making 20 passes in a 4100-pound station wagon driven at 40 MPH past a sampler 100 feet from the road centerline. Measurements were taken downwind of dry unpaved surfaces during sunny afternoons with wind speeds of 5 to 10 MPH.

Ambient size distributions and associated concentrations were measured on the Iowa State University campus and at the Iowa Coal Project mine site office. Background levels at the mine site were measured in absence of any mining activity (i.e., on Saturday afternoon) upwind from the mining pit. The ambient sample on the ISU campus yielded comparable results. Concentrations and particulate-size distributions at the site were measured at approximately 50 meters and 500 meters downwind of the mining operation during very similar meteorological conditions. Concentrations at these distances would be representative of levels frequently experienced by office administrators and support personnel within the ICP site boundaries, but not those personnel directly involved in heavy-equipment operation. A very limited amount of data was available representative of conditions actually experienced by mining personnel operating heavy equipment. Some of the data are questionable, but they do allow order-of-magnitude estimates where air-quality measurements are difficult to obtain.

For comparative purposes Iowa City and Des Moines particle-size distribution data were chosen as background estimates for the central-southeast Iowa area. These are the only size-distribution data available for this part of the state, according to Iowa Department of Environmental Quality personnel. Interpolation between Iowa City and Des Moines is not recommended because these two locations are predominantly urban and the ICP mine site is rural.

B. Standard 24-Hour High-Volume Suspended-Particulate Data

Beginning August 28, 1976, standard twenty-four hour suspended-particulate samples were collected on a schedule closely matching the present six-day cycle used by the Iowa Department of Environmental Quality (DEQ). These samples were collected in the immediate vicinity of the mine-site office so as to be representative of possible "worst-case" conditions that might be experienced by local residents adjacent to the mine. On December 3, 1976, the frequency of 24-hour high-volume air samples was increased to approximately one every three days. Because of instrument malfunctions during the record cold weather of December 1976 and January 1977, there were frequent departures from the standard DEQ sampling schedule. The DEQ concentrations were assumed as representative of an overall ambient average typifying eastern Marion, western Mahaska, northern Monroe and northwestern Wapello counties. These nearby sampling locations were selected for comparison because of their proximity to the mine site. The gravimetric technique for measuring concentrations of suspended particulates was used at these sites, so these data should be comparable to our data in accuracy, handling, procedure and analysis. The three locations were the (1) Municipal Building, Ottumwa, Iowa; (2) Douma School, Ottumwa, Iowa; and (3) 216 Liberty Street, Pella, Iowa. The data records at all three locations are relatively short, with the longest data period extending from January 1975 to the present at the Municipal Building in Ottumwa.

C. Hourly Meteorological Data

On-site meteorological data recorded on 28-day strip charts were reduced to either hourly averages and/or extrema, or running totals. The parameter causing the greatest data-reduction problem was wind direction, which has averages and extremes that are meaningless in either calm or light-and-variable conditions. The wind-direction measurement for each hour was assigned one of sixteen sector values for its average direction over the hour, together with an angular measurement of variability over the hour. Hourly wind-direction variability was defined as the angular region including 99.1% of the observations ($\pm$ 2.615 standard deviations). If this range exceeded 180 degrees, that hour was classified as "variable". Maximum, minimum, and average hourly wind-speed values were recorded in miles per hour. Solar radiation was recorded in langleys/hour (1 langley = 1 gm-cal/cm^2); hourly precipitation was recorded to the nearest 0.01 inch. Maximum and minimum hourly values of temperature and relative humidity were recorded to the nearest 1°F and 1%, respectively.

IV. DATA ANALYSIS

A. Ambient Conditions

Before determining the impact of surface-mining operations, it is first necessary to have an overall assessment of background levels of the pollutant under consideration. Size distribution data of suspended particles for three locations in Des Moines and one in Iowa City are given in Tables 2, 3, 4 and 5 respectively. These data together with the fate of inhaled particles (see Section II. B.) indicate that about 33% to 43% of all particulates are 7 microns in diameter or larger, and are likely to be collected by nasal hair, the remaining 47% to 57% will be deposited deeper within the human respiratory system. These data suggest that the approximate expected proportions of trapped deposits are 15% to 19% by the trachea and primary bronchi, 10% to 13% by the secondary bronchi, 5% to 10% by the terminal bronchi, and 25% to 32% by the alveoli. The above percentages provide a guide to the interpretation of particulate size-distribution data. Particles greater than 7 microns in diameter together with those in the submicron group account for nearly 80% to 90% of all inhaled particulates.

Most data pertaining to suspended particulates were obtained using a high-volume air flow and gravimetric technique. Although these data are not as informative as size distributions, they are easier to obtain and analyze; hence most governmental agencies use this method, especially in smaller urban areas. Two such samplers are in Ottumwa and one in Pella. Data from these are given in Tables 6, 7 and 8. Significant annual or seasonal trends cannot be inferred from such a limited data base. Tables 6, 7 and 8 indicate the Douma School site in Ottumwa and the Pella site have similar atmospheric particulate concentrations, but downtown Ottumwa seems to be more strongly influenced by

Table 2

1975 Suspended-Particulate Sizing Data in Percent
Des Moines, Iowa - West Location
(Maquoketa at Forestdale)

Date	Submicron (<1.1μ)	1.1μ-2.0μ	2.0μ-3.3μ	3.3μ-7.0μ	>7.0μ
	Particle-Size Distribution in Microns				
5 AUG 75	29	10	12	17	32
7 AUG 75	31	8	11	17	32
8 AUG 75	31	8	11	17	34
19 AUG 75	38	3	11	13	35
7 OCT 75	32	1	15	16	35
9 OCT 75	14	3	14	19	49
12 OCT 75	23	4	13	17	43
16 OCT 75	26	2	4	19	48
18 OCT 75	40	8	6	17	30
22 OCT 75	26	6	11	17	40
28 OCT 75	30	5	11	17	36
2 NOV 75	38	9	12	14	28
5 NOV 75	27	12	12	16	32
8 NOV 75	44	9	10	9	28
14 NOV 75	42	1	3	13	41
17 NOV 75	31	7	9	17	37
AVERAGE	31.4	6.0	10.3	16.0	36.3

Table 3

1975 Suspended-Particulate Sizing Data in Percent

Des Moines, Iowa - East Location

(Arthur at Oxford)

Date	Submicron (<1.1μ)	Particulate-Size Distribution in Microns 1.1μ-2.0μ	2.0μ-3.3μ	3.3μ-7.0μ	>7.0μ
5 AUG 75	23	10	13	19	35
7 AUG 75	27	6	11	18	38
10 AUG 75	30	9	11	16	34
13 AUG 75	23	7	11	18	40
18 AUG 75	32	8	13	14	33
20 AUG 75	27	6	11	15	42
4 OCT 75	27	5	12	15	40
10 OCT 75	16	4	10	16	55
13 OCT 75	24	5	13	15	43
19 OCT 75	18	2	6	18	56
23 OCT 75	25	5	13	15	43
25 OCT 75	29	3	15	16	37
29 OCT 75	20	6	10	16	48
3 NOV 75	20	6	9	15	50
AVERAGE	24.4	5.8	11.3	16.1	42.4

Table 4

1975 Suspended-Particulate Sizing Data in Percent

Des Moines, Iowa - South Location

(Kirkwood at Courtland)

Particle-Size Distribution in Microns

Date	Submicron (<1.1μ)	1.1μ-2.0μ	2.0μ-3.3μ	3.3μ-7.0μ	>7.0μ
13 AUG 75	27	8	11	15	39
17 AUG 75	25	10	13	20	33
18 AUG 75	33	7	11	15	33
19 AUG 75	36	7	9	13	35
20 AUG 75	27	1	11	16	45
5 OCT 75	12	6	14	18	50
8 OCT 75	23	4	13	15	44
11 OCT 75	22	2	12	17	47
14 OCT 75	28	1	2	16	53
17 OCT 75	25	4	8	16	47
20 OCT 75	20	4	6	17	52
26 OCT 75	33	5	13	17	33
1 NOV 75	40	2	10	14	34
4 NOV 75	32	7	9	12	41
7 NOV 75	31	2	9	14	43
16 NOV 75	30	7	11	20	32
22 NOV 75	34	4	9	14	41
AVERAGE	28.1	4.8	10.0	15.8	41.3

Table 5

1976 Particulate-Sizing Data in Percent
State Hygienic Lab., Iowa City, Iowa

Date	Submicron (<1.1μ)	1.1μ to 2.0μ	2.0μ to 3.3μ	3.3μ to 7.0μ	>7.0μ
	Particle-Size Distribution in Microns				
3 OCT 76	28.1	8.3	14.6	21.1	27.9
9 OCT 76	25.9	6.4	7.8	16.1	43.9
15 OCT 76	26.0	8.7	12.0	21.4	31.8
21 OCT 76	31.7	9.8	11.5	19.3	27.7
27 OCT 76	24.5	9.9	11.7	20.4	33.5
2 NOV 76	26.3	8.2	10.5	17.9	37.2
8 NOV 76	33.3	7.5	10.3	16.8	32.1
14 NOV 76	15.3	10.9	10.9	21.4	41.5
20 NOV 76	24.3	6.6	10.0	20.3	38.9
26 NOV 76	32.1	6.5	8.2	13.6	39.6
2 DEC 76	30.8	11.5	13.5	17.9	26.4
8 DEC 76	37.6	10.5	12.3	15.4	24.2
14 DEC 76	31.3	11.1	10.9	17.6	29.1
20 DEC 76	23.3	9.3	12.0	18.7	37.3
26 DEC 76	23.1	9.2	11.9	18.6	37.0
AVERAGE	27.6	8.9	11.2	18.4	33.9

1977 Particulate-Sizing Data in Percent
State Hygienic Lab, Iowa City, Iowa

1 JAN 77	28.8	8.9	11.8	17.4	33.1
7 JAN 77	23.0	11.6	12.7	18.1	34.6
13 JAN 77	30.5	14.7	15.5	16.7	22.6
19 JAN 77	33.9	5.9	14.9	18.1	28.2
25 JAN 77	19.5	8.8	10.0	13.5	48.2
31 JAN 77	15.7	6.0	8.6	12.7	57.0
6 FEB 77	31.7	9.7	11.1	15.3	32.3
12 FEB 77	30.6	8.9	12.4	18.9	29.2
18 FEB 77	25.1	8.2	10.8	17.7	38.3
24 FEB 77	27.3	8.6	10.4	16.2	37.5
2 MAR 77	26.5	12.3	13.3	17.7	30.2
8 MAR 77	11.2	10.2	15.1	22.9	40.7
14 MAR 77	17.6	10.1	13.2	21.9	37.1
20 MAR 77	41.9	13.0	11.4	13.6	20.2
26 MAR 77	15.2	11.5	13.9	21.2	38.2
AVERAGE	25.2	9.9	12.3	17.5	35.2

Table 6

Monthly Suspended-Particulate Data
Ottumwa, Iowa - Municipal Building
(micrograms per cubic meter)

Month	Arithmetic Mean	Standard Deviation	Geometric Mean	Geometric Standard Deviation
APR 74	111.06	22.79	109.16	0.2090
MAY 74	112.25	23.77	110.39	0.2111
JUN 74	83.24	59.84	63.89	0.8725
JUL 74	87.62	30.31	83.26	0.3635
AUG 74	82.72	51.37	70.16	0.6480
SEP 74	72.84	24.73	68.65	0.4110
OCT 74	95.10	64.36	83.44	0.5196
NOV 74	122.40	108.33	96.25	0.7263
DEC 74	60.36	36.50	53.46	0.5282
JAN 75	57.76	17.77	55.71	0.2982
FEB 75	79.05	44.61	67.47	0.7056
MAR 75	116.90	43.09	110.11	0.3956
APR 75	104.28	24.60	101.92	0.2415
MAY 75	119.52	46.28	112.40	0.3965
JUN 75	112.88	23.48	110.90	0.2113
JUL 75	100.02	38.26	92.22	0.4894
AUG 75	86.96	12.78	86.21	0.1470
SEP 75	55.32	14.16	53.70	0.2813
OCT 75	108.20	37.40	103.11	0.3476
NOV 75	53.46	27.98	48.16	0.5100
DEC 75	45.76	13.92	44.25	0.2832
JAN 76	75.27	51.27	63.32	0.6288
FEB 76	99.00	35.18	93.33	0.4190
MAR 76	63.42	43.19	55.33	0.5234
APR 76	94.82	32.78	90.64	0.3301
MAY 76	69.72	15.89	68.79	0.2278
JUN 76	90.22	5.67	90.07	0.0644
JUL 76	103.88	20.84	102.08	0.2142
AUG 76	107.63	25.75	105.60	0.2182
SEP 76	78.16	11.07	77.58	0.1339
OCT 76	156.50	100.55	138.03	0.5208
NOV 76	101.33	49.71	90.86	0.5661
DEC 76	83.94	38.91	76.18	0.5079
JAN 77	73.00	32.10	67.28	0.4436
FEB 77	107.08	18.70	105.82	0.1785

Table 7

Monthly Suspended-Particulate Data
Ottumwa, Iowa - Douma School
(micrograms per cubic meter)

Month	Arithmetic Mean	Standard Deviation	Geometric Mean	Geometric Standard Deviation
MAY 76	52.68	11.56	51.70	0.2153
JUN 76	66.30	21.28	63.51	0.3337
JUL 76	80.63	8.53	80.29	0.1051
AUG 76	64.78	20.71	62.31	0.3080
SEP 76	79.16	38.32	72.03	0.4926
OCT 76	111.40	82.72	94.55	0.6166
NOV 76	82.58	31.38	76.16	0.4908
DEC 76	43.50	8.23	42.81	0.2063
JAN 77	40.95	16.21	38.86	0.3364
FEB 77	47.00	5.57	46.74	0.1248

Table 8

Monthly Suspended-Particulate Data
Pella, Iowa - 216 Liberty St.
(micrograms per cubic meter)

Month	Arithmetic Mean	Standard Deviation	Geometric Mean	Geometric Standard Deviation
JAN 76	46.90	21.02	43.46	0.4294
FEB 76	48.83	21.41	44.46	0.5343
MAR 76	47.35	42.89	33.68	0.8846
APR 76	57.18	41.13	41.84	0.9736
MAY 76	109.00	N.A.	109.00	N.A.
JUN 76	74.25	17.50	72.83	0.2224
JUL 76	63.85	3.78	63.77	0.0593
AUG 76	83.64	13.88	83.64	0.1769
SEP 76	74.22	34.21	68.32	0.4505
OCT 76	70.08	11.22	69.34	0.1644
NOV 76	70.76	15.14	69.26	0.2412
DEC 76	40.68	8.31	40.03	0.1995
JAN 77	36.54	10.29	35.27	0.3066
FEB 77	35.27	4.03	35.12	0.1110

local pollution sources. We recommend that, in spite of the shorter data bases, the Douma School and Pella locations be used to establish ambient atmospheric particulate concentrations.

Monthly mean concentrations at the three sites ranged from 35 to 150 micrograms per cubic meter ($\mu g/m^3$). Corresponding monthly geometric means were typically 5 to 15 $\mu g/m^3$ less than the arithmetic mean value. Variances from month to month differ considerably depending on local industrial and traffic patterns as well as seasonal weather changes. The log-normal distribution is frequently used to approximate the actual particulate-size spectra and annual distributions (Larsen, 1969; Hale, 1972). This is especially true for ambient conditions that are not biased by numerous larger particles typically present near particulate sources.

The graph and accompanying table in Appendix A show the distribution of particulate concentrations to resemble the log-normal distribution. If the distributions were exactly log normal, the data points would lie on a straight line. These data suggest that particulate concentrations observed at the ICP mine site and on the Iowa State University campus are approximately log-normally distributed during non-active periods. Other studies (Mainwaring, 1976) suggest the log-normal distribution to be most appropriate for characterizing particulate levels in industrial and urban areas.

B. Dust From Haul Roads

Data from the three road studies described in Section III. A. (see Table 9) show the shift of the size spectra toward larger particles. Data in Table 9 were collected during dry conditions when dust concentrations were above normal and are not representative of wet periods. Roadway surfaces tend to dry

Table 9

Iowa Coal Project Particulate-Sizing Date in Percent During Dry Conditions

Location	Date	submicron (<1.1μ)	1.1μ to 2.0μ	2.0μ to 3.3μ	3.3μ to 7.0μ	>7.0μ
			Particle-Size Distribution in Microns			
A. Ambient Measurements						
ICP Mine Site	18 SEP 76	36.1	8.5	11.9	11.5	32.0
ISU Campus	23 AUG 76	36.8	8.4	7.4	14.2	33.2
Average		36.4	8.5	9.7	12.8	32.6
B. Activity Measurements						
ICP Mine Site 50m downwind	18 SEP 76	32.2	7.0	12.2	17.6	31.0
ICP Mine Site 500m downwind	11 SEP 76	21.5	6.4	13.2	21.6	37.3
Average		26.8	6.7	12.7	19.6	34.2
C. Gravel Road Measurements						
Story County Gravel Road	31 AUG 76	14.4	4.4	13.1	24.8	43.3
Mahaska County Gravel Road	27 AUG 76	20.9	1.5	7.5	31.3	38.8
Mahaska County Gravel Road	11 SEP 76	11.1	4.6	10.1	21.3	51.9
Average		15.5	3.5	10.2	26.1	44.7

off very rapidly if meteorological conditions are conducive or the traffic flow is moderate; the results are, therefore, representative of conditions that frequently exist. The percentage of particulates greater than or equal to 7μ is increased approximately 5% to 15% above normal ambient levels, and increases of 5% to 10% are observed in the next smaller range. To a lesser degree, smaller-size ranges also show an increase. This is expected because fewer large particles are required to shift the size spectra due to the greater mass per particle.

Dust concentrations from traffic on gravel roads are extremely variable over short distances. Dust plumes are observed to maintain their original shape for considerable distances downwind over open fields. In the vicinity of farmsteads, increased surface roughness (i.e., trees, shrubs, buildings) enhances mixing and slows horizontal transport thereby increasing local deposition.

Table 10 shows the percentage of the total contribution below a graphically-determined aerodynamic particle diameter for three road-dust studies. Typically, 50% of the dust particles generated by passing vehicles have aerodynamic diameters of approximately 5.4 to 7.5 microns or less. Average point concentrations are extremely difficult to measure due to the rapidly changing plume characteristics as a function of space and time. Gravel-road measurements also seem to be distributed log normally.

C. Dust From Mining Activity

Table 11 contains daily high-volume suspended-particulate concentrations collected since July 1, 1976, from the ICP mine site, two locations in Ottumwa, and one in Pella, Iowa. Monthly values of the arithmetic mean, standard deviation, geometric mean, and geometric standard deviation are also included.

Table 10

Iowa Coal Project Particulate-Sizing Data - Aerodynamic Particle Diameter in Microns

Location	Date	Percentage less than for an aerodynamic diameter					
		20%	30%	40%	50%	60%	70%
A. Gravel Road Measurements							
Story County Gravel Road	31 AUG 76	2.1	3.1	4.3	5.8	~7.6[a]	N.A.
Mahaska County Gravel Road	27 AUG 76	~0.7[a]	3.3	4.3	5.4	6.9	N.A.
Mahaska County Gravel Road	11 SEP 76	2.6	3.9	5.5	~7.5[a]	~10[a]	N.A.
B. Mine Measurements							
ICP Mine Site 500m downwind	11 SEP 76	N.A.	2.2	3.1	4.4	6.4	~9[a]
ICP Mine Site 50m downwind	18 SEP 76	N.A.	~0.95[a]	2.0	3.0	4.6	~7.2[a]
ICP Mine Site - no activity	18 SEP 76	N.A.	~0.7[a]	1.5	2.5	4.2	~8[a]
ISU Campus - no activity[b]	23 AUG 76	N.A.	~0.7[a]	1.4	2.9	5.0	~8.5[a]

a - Extrapolated Aerodynamic Particle Diameter

b - Air Pollution Advisories were in effect for part of the sampling period

Table 11

High-Volume Gravimetric
Suspended-Particulate Concentrations
(micrograms per cubic meter)

Date	Iowa Coal Project Mine-Site Office	State Hygienic Lab Ottumwa, Iowa Municipal Building	State Hygienic Lab Ottumwa, Iowa Douma School	State Hygienic Lab Pella, Iowa 216 Liberty St.
5 JUL 76	N.A.	131.0	74.9	61.1
11 JUL 76	N.A.	107.0	84.4	66.9
17 JUL 76	N.A.	105.0	90.8	67.3
23 JUL 76	N.A.	104.0	72.4	60.1
29 JUL 76	N.A.	72.4	N.A.	N.A.
Arithmetic Mean	N.A.	103.88	80.63	63.85
Standard Deviation	N.A.	20.84	8.53	3.78
Geometric Mean	N.A.	102.08	80.29	63.77
Geo. Std. Dev.	N.A.	.2142	.1051	.0593
4 AUG 76	N.A.	98.6	49.3	92.0
10 AUG 76	N.A.	N.A.	62.6	62.2
16 AUG 76	N.A.	146.0	44.4	83.5
22 AUG 76	N.A.	94.5	96.7	99.0
28 AUG 76	302.1	91.4	70.9	81.5
Arithmetic Mean	302.1	107.63	64.78	83.64
Standard Deviation	N.A.	25.75	20.71	13.88
Geometric Mean	302.1	105.60	62.31	82.64
Geo. Std. Dev.	N.A.	.2182	.3080	.1769
3 SEP 76	157.5	96.9	81.7	121.0
9 SEP 76	N.A.	67.5	62.9	50.5
10 SEP 76	≃ 1200.	N.A.	N.A.	N.A.
15 SEP 76	N.A.	74.0	75.5	99.7
16 SEP 76	390.1	N.A.	N.A.	N.A.
21 SEP 76	630.4	75.8	140.0	57.1
27 SEP 76	37.5	76.6	35.7	42.8
Arithmetic Mean	483.10	78.16	79.16	74.22
Standard Deviation	460.67	11.07	38.32	34.21
Geometric Mean	280.71	77.58	72.03	68.32
Geo. Std. Dev.	1.3472	.1339	.4926	.4505

Table 11 cont.

High-Volume Gravimetric
Suspended-Particulate Concentrations
(micrograms per cubic meter)

Date	Iowa Coal Project Mine-Site Office	State Hygienic Lab Ottumwa, Iowa Municipal Building	State Hygienic Lab Ottumwa, Iowa Douma School	State Hygienic Lab Pella, Iowa 216 Liberty St.
3 OCT 76	0.3	92.9	74.6	79.5
9 OCT 76	N.A.	140.0	76.1	71.9
11 OCT 76	603.2	N.A.	N.A.	N.A.
15 OCT 76	604.3	333.0	N.A.	61.4
16 OCT 76	N.A.	N.A.	235.0	N.A.
21 OCT 76	N.A.	121.0	N.A.	81.7
22 OCT 76	199.5	N.A.	N.A.	N.A.
27 OCT 76	558.5	95.6	N.A.	55.9
28 OCT 76	N.A.	N.A.	59.9	N.A.
Arithmetic Mean	393.16	156.50	111.40	70.08
Standard Deviation	277.43	100.55	82.72	11.22
Geometric Mean	104.03	138.03	94.55	69.34
Geo. Std. Dev.	3.3030	.5208	.6166	.1644
2 NOV 76	386.9	126.0	N.A.	69.2
3 NOV 76	N.A.	N.A.	72.6	N.A.
8 NOV 76	540.9	79.9	96.0	72.0
14 NOV 76	119.5	156.0	96.0	83.7
20 NOV 76	N.A.	N.A.	115.0	82.7
22 NOV 76	196.7	N.A.	N.A.	N.A.
26 NOV 76	N.A.	43.4	33.3	46.2
29 NOV 76	24.9	N.A.	N.A.	N.A.
Arithmetic Mean	253.78	101.33	82.58	70.76
Standard Deviation	208.47	49.71	31.38	15.14
Geometric Mean	165.05	90.86	76.16	69.26
Geo. Std. Dev.	1.2090	.5661	.4908	.2412
2 DEC 76	N.A.	N.A.	N.A.	35.0
3 DEC 76	N.A.	40.2	N.A.	N.A.
4 DEC 76	N.A.	N.A.	30.4	N.A.
7 DEC 76	124.6	N.A.	N.A.	N.A.
8 DEC 76	26.1	50.2	44.3	44.9
13 DEC 76	191.1	N.A.	N.A.	N.A.
14 DEC 76	396.4	102.0	45.6	52.8
17 DEC 76	301.4	N.A.	N.A.	N.A.
20 DEC 76	N.A.	135.0	44.0	38.7
23 DEC 76	951.5	N.A.	N.A.	N.A.
26 DEC 76	N.A.	92.3	53.2	32.0
27 DEC 76	693.0	N.A.	N.A.	N.A.
29 DEC 76	78.3	N.A.	N.A.	N.A.
Arithmetic Mean	345.30	83.94	43.50	40.68
Standard Deviation	324.82	38.91	8.23	8.31
Geometric Mean	210.35	76.18	42.81	40.03
Geo. Std. Dev.	1.1859	.5079	.2063	.1995

Table 11 cont.

High-Volume Gravimetric
Suspended-Particulate Concentrations
(micrograms per cubic meter)

Date	Iowa Coal Project Mine-Site Office	State Hygienic Lab Ottumwa, Iowa Municipal Building	State Hygienic Lab Ottumwa, Iowa Douma School	State Hygienic Lab Pella, Iowa 216 Liberty St.
1 JAN 77	N.A.	115.0	72.8	49.4
2 JAN 77	88.1	N.A.	N.A.	N.A.
5 JAN 77	121.2	N.A.	N.A.	N.A.
7 JAN 77	N.A.	52.4	37.0	N.A.
13 JAN 77	N.A.	39.0	38.4	42.0
14 JAN 77	68.8	N.A.	N.A.	N.A.
17 JAN 77	68.5	N.A.	N.A.	N.A.
18 JAN 77	14.8	N.A.	N.A.	N.A.
19 JAN 77	N.A.	48.9	37.7	22.0
25 JAN 77	13.8	108.0	26.6	36.9
26 JAN 77	616.8	N.A.	N.A.	N.A.
27 JAN 77	145.8	N.A.	N.A.	N.A.
28 JAN 77	70.2	N.A.	N.A.	N.A.
29 JAN 77	54.7	N.A.	N.A.	N.A.
31 JAN 77	38.2	74.7	33.2	32.4
Arithmetic Mean	118.23	73.00	40.95	36.54
Standard Deviation	170.18	32.10	16.21	10.29
Geometric Mean	67.46	67.28	38.86	35.27
Geo. Std. Dev.	1.0578	.4436	.3364	.3066
3 FEB 77	94.9	N.A.	N.A.	N.A.
6 FEB 77	111.0	97.7	48.9	N.A.
9 FEB 77	163.3	N.A.	N.A.	N.A.
12 FEB 77	203.1	126.0	48.2	32.6
15 FEB 77	161.4	N.A.	N.A.	N.A.
18 FEB 77	546.1	119.0	51.9	39.9
21 FEB 77	354.2	N.A.	N.A.	N.A.
24 FEB 77	138.2	85.6	39.0	33.3
27 FEB 77	123.8	N.A.	N.A.	N.A.
Arithmetic Mean	210.67	107.08	47.00	35.27
Standard Deviation	147.47	18.70	5.57	4.03
Geometric Mean	178.78	105.82	46.74	35.12
Geo. Std. Dev.	.5678	.1785	.1248	.1110

Table 11 cont.

High-Volume Gravimetric
Suspended-Particulate Concentrations
(micrograms per cubic meter)

Date	Iowa Coal Project Mine-Site Office	State Hygienic Lab Ottumwa, Iowa Municipal Building	State Hygienic Lab Ottumwa, Iowa Douma School	State Hygienic Lab Pella, Iowa 216 Liberty St.
5 MAR 77	228.3	N.A.	N.A.	N.A.
7 MAR 77	296.5	N.A.	N.A.	N.A.
9 MAR 77	134.5	N.A.	N.A.	N.A.
11 MAR 77	173.5	N.A.	N.A.	N.A.
14 MAR 77	145.6	N.A.	N.A.	N.A.
17 MAR 77	154.5	N.A.	N.A.	N.A.
20 MAR 77	141.5	N.A.	N.A.	N.A.
23 MAR 77	208.5	N.A.	N.A.	N.A.
26 MAR 77	437.1	N.A.	N.A.	N.A.
29 MAR 77	613.3	N.A.	N.A.	N.A.
Arithmetic Mean	253.33	N.A.	N.A.	N.A.
Standard Deviation	157.13	N.A.	N.A.	N.A.
Geometric Mean	221.25	N.A.	N.A.	N.A.
Geo. Std. Dev.	0.5168	N.A.	N.A.	N.A.

Date	Iowa Coal Project Mine-Site Office	State Hygienic Lab Ottumwa, Iowa Municipal Building	State Hygienic Lab Ottumwa, Iowa Douma School	State Hygienic Lab Pella, Iowa 216 Liberty St.
1 APR 77	136.1	N.A.	N.A.	N.A.
4 APR 77	91.1	N.A.	N.A.	N.A.
7 APR 77	248.2	N.A.	N.A.	N.A.
Arithmetic Mean	158.47	N.A.	N.A.	N.A.
Standard Deviation	145.45	N.A.	N.A.	N.A.
Geometric Mean	80.90	N.A.	N.A.	N.A.
Geo. Std. Dev.	0.5044	N.A.	N.A.	N.A.

Typically, the mean monthly concentrations at the site office were 1.5 to 8.5 times greater than the "ambient" values measured in Ottumwa and Pella. Despite the variability among the three locations, average monthly concentrations at the mine site always exceeded those of the other three during the seven-month period. Monthly standard deviations indicate greater local variability at the mine site than at Ottumwa and Pella. Monthly standard deviations at the mine site ranged from a maximum of 460 micrograms per cubic meter ($\mu g/m^3$) in September 1976 to a minimum of 147 $\mu g/m^3$ in February 1977, whereas in Ottumwa and Pella the corresponding range was from 4 $\mu g/m^3$ to 100 $\mu g/m^3$. Appendix B gives definitions of the geometric mean, geometric standard deviation, arithmetic mean, and standard deviation. Monthly geometric standard deviations at the mine site ranged from a minimum of 0.57 in February 1977 to a maximum of 3.30 in October 1976; in Ottumwa and Pella the range was from 0.06 at Pella in July 1976 to 0.61 at the Douma School in Ottumwa during October 1976. From these values it is evident there are overall higher background levels and greater variances in 24-hour sample concentrations at the mine site.

Table 12, a condensed form of Table 11, lists data that represent approximately concurrent sampling times and similar meteorology. Again, 24-hour particulate samples from the site tend to have higher mean concentrations and variances than the surrounding communities. The arithmetic mean at the mine site ranged from 2.5 to 4.5 times greater than corresponding means in Ottumwa and Pella based on these 18 cases. The standard deviation at the mine site was 229.21 $\mu g/m^3$ versus 58.68 $\mu g/m^3$ based on daily averages of the three surrounding sample locations. Particulate-concentration correlation coefficients between the mine site, and Ottumwa and Pella locations are given in Table 13. These suggest that increases in particulate concentrations at the mine site are

Table 12

Approximately 24-Hour Concurrent
Suspended-Particulate Concentrations
(micrograms per cubic meter)

Date	ICP Mine-Site	State Hygienic Lab Ottumwa, Iowa Municipal Building	State Hygienic Lab Ottumwa, Iowa Douma School	State Hygienic Lab Pella, Iowa 216 Liberty St.	State Hygienic Lab Average Concentrations
28 AUG 76	302.1	91.4	70.9	81.5	81.27
3 SEP 76	157.5	96.9	81.7	121.0	99.87
21 SEP 76	630.4	75.8	140.0	57.1	90.97
27 SEP 76	37.5	76.6	35.7	42.8	51.70
3 OCT 76	.3	92.9	74.6	79.5	82.33
15 OCT 76	604.3	333.0	N.A.	61.4	197.20
27 OCT 76	558.5	95.6	N.A.	55.9	75.75
2 NOV 76	386.9	126.0	N.A.	69.2	97.60
8 NOV 76	540.9	79.9	96.0	72.0	82.63
14 NOV 76	119.5	156.0	96.0	83.7	111.90
8 DEC 76	26.1	50.2	44.3	44.9	46.47
14 DEC 76	396.4	102.0	45.6	52.8	66.80
25 JAN 77	13.8	108.0	26.6	36.9	57.17
31 JAN 77	38.2	74.7	33.2	32.4	46.77
6 FEB 77	111.0	97.7	48.9	N.A.	73.30
12 FEB 77	203.1	126.0	48.2	32.6	68.93
18 FEB 77	546.1	119.0	51.9	39.9	70.27
24 FEB 77	138.2	85.6	39.0	33.3	52.63
Arithmetic Mean	267.27	110.41	62.17	58.64	80.75
Standard Deviation	229.21	60.53	30.90	23.83	58.68

Table 13

Suspended-Particulate Concentration Correlation Coefficients[a]
Between the IOWA COAL PROJECT and Selected
Iowa Department of Environmental Quality Locations

	Iowa Coal Project Mine-Site Office	Ottumwa, Iowa Municipal Bldg.	Ottumwa, Iowa Douma School	Pella, Iowa 216 Liberty St.	State Hygienic Lab Average Value[b]
Iowa Coal Project Mine-Site Office	+1.00	+0.37	+0.59	+0.07	+0.49
Ottumwa, Iowa Municipal Bldg.	+0.37	+1.00	+0.08	+0.10	N.A.
Ottumwa, Iowa Douma School	+0.59	+0.08	+1.00	+0.58	N.A.
Pella, Iowa 216 Liberty St.	+0.07	+0.10	+0.58	+1.00	N.A.

[a] Data based on Table 12

[b] Average value is based on the arithmetic mean of concurrent State Hygienic Lab particulate samples.

fairly well correlated with increases at the Douma School in Ottumwa. A lesser correlation exists between the mine site and the Municipal Building in Ottumwa, and almost no correlation between the mine site and the Pella site. Correlation coefficients were also computed for the surrounding sampling locations with values ranging from 0.10 between Pella and the Municipal Building in Ottumwa, to 0.58 between Pella and the Douma School in Ottumwa. The correlations indicate the importance of a proper ambient location when attempting to define background levels and daily differences due to local pollution sources and meteorological conditions. Table 13 suggests that, of the available locations, the Douma School represents the best site for establishing ambient particulate concentrations.

Total and seasonal correlation coefficients of 24-hour-average wind speed based on Des Moines 3-hourly surface data versus 24-hour suspended particulate concentration are given in Table 14. These data indicate two simultaneously opposing effects. The dispersion potential of atmospheric pollutants is directly proportional to wind speed; and above some threshold velocity, saltation and particulate-lifting commence, resulting in concentration increases due to fugitive dust. From our data it is impossible to separate these two components. A positive correlation between wind speed and dust concentrations is observed for the total data set at the Municipal Building in Ottumwa, and a negative correlation is observed for the total data set at the Douma School site. These results may be expected because the downtown Ottumwa location is more susceptible to wind-blown dust from local traffic and industry, whereas the Douma School is located in an area of relatively lower mean monthly particulate concentrations. The mine site does not strictly resemble either

Table 14

TOTAL DATA PERIOD AND SEASONAL CORRELATION COEFFICIENTS OF
24-HOUR AVERAGE WIND SPEED[a] VERSUS
24-HOUR SUSPENDED-PARTICULATE CONCENTRATIONS

24-Hour Suspended Particulate Sample Locations and Data Period

Season	Iowa Coal Project Mine-Site Office (28 AUG 76-28 FEB 77)	State Hygienic Lab Ottumwa, Iowa Municipal Building (1 JAN 76-28 FEB 77)[b]	State Hygienic Lab Ottumwa, Iowa Douma School (1 MAY 76-28 FEB 77)[b]	State Hygienic Lab Pella, Iowa 216 Liberty St. (7 JAN 76-28 FEB 77)[b]
Spring	N.A.	+0.10	-0.26	+0.08
Summer	N.A.	-0.03	-0.64	+0.13
Autumn	-0.04	+0.38	-0.40	-0.27
Winter	-0.05	+0.37	-0.08	+0.10
Total Data Period	-0.17	+0.17	-0.30	-0.31

[a] Local Climatological Data for Des Moines, Iowa, 1 JAN 76-28 FEB 77.

[b] Suspended-Particulate Data from the Iowa Department of Environmental Quality, Des Moines, Iowa.

a rural or urban environment, and hence it does not correlate with Des Moines wind speed in a manner exactly similar to any of the three surrounding locations. The Municipal Building with its urban influence indicates a positive total correlation of particulate concentrations and wind speed, whereas the Douma School with its rural influence indicates a negative total correlation of particulate concentrations and wind speed. The mine site has a total correlation coefficient between these two values. A possible explanation is that upwind of the mining operation, the air is relatively clean, typical of rural areas with relatively few sources of particulates. However within the site boundaries, a large fetch of exposed ground is usually present, increasing the potential of high surface-particulate concentrations, especially if winds exceed the minimum speed to initiate saltation.

Two cases are cited in Table 10 where average dust concentrations were measured at approximately 50 and 500 meters downwind of the mining operation. The median aerodynamic diameters downwind of the operation, which ranged from 3.0 to 4.4 microns, were less than the median aerodynamic diameters measured on the gravel roads. At 50 m downwind of the mine activity the median aerodynamic diameter was 3.0μ, and at 500 meters downwind it was 4.4μ, whereas the average median aerodynamic diameter for gravel-road-generated particles was approximately 6.2 microns.

Superimposing additional dust concentrations from mining activity upon concentrations from ambient and naturally occurring sources, such as saltation and particulate lifting, increases the complexity of the component contributions that are impossible to resolve using standard high-volume sampling techniques. This complexity is stated as a potential source of difficulty in future experimental designs. Data from Table 9 do indicate an overall skewness of the particulate distribution in the immediate vicinity of earth-hauling equipment as compared to similar measurements further downwind. It should be noted that measurements were taken on different days and in different regions of the mine-site area, and overall particle-size proportions within individual samples should be considered as single point-source estimators with unknown variances. However, this first-hand information does offer some insight into the overall dust problem associated with a surface-mine operation.

Eleven dust samples representing concentrations frequently experienced by mining personnel are given in Table 15. The samples are eight-hour averages taken at different phases of the mining operation. Generally administration personnel and truck drivers are exposed to the lowest concentrations, usually in the range of 0.1 to 0.2 milligrams per cubic meter (mg/m^3); with occasional dust episodes reaching 0.4 milligrams per cubic meter. Dozer and front-end-loader operators experienced concentrations of 0.4 to 0.5 mg/m^3. The largest average dust concentrations were experienced by mining personnel operating scrapers in till areas. Under these conditions concentrations of 0.7 to 0.8 milligrams per cubic meter were measured.

D. Conclusion

Suspended-particulate emissions associated with the mining, handling, and transportation of coal in Iowa, make suspended particulates the single worst pollutant threatening to violate present air quality standards. Surface strip-mining operations produce 24-hour particulate concentrations that average greater than surrounding areas, and produce greater daily variability. High daily averages and variability are due to two simultaneous occurring effects - a large potential dust source approaching urban levels, surrounded by low ambient background levels. Topographical differences and rapid meteorological changes result in a wide range of atmospheric dispersion conditions.

Table 15

Iowa Coal Project Dust Samples for
Mining Personnel as Required by the
Mining Enforcement and Safety Administration
(milligrams per cubic meter)

Date	Concentration (mg/m^3)	Equipment/Location
22 DEC 75	0.5	Dozer
30 JAN 76	0.4	Trailor
17 FEB 76	0.5	Dozer (push cat behind scraper)
19 FEB 76	0.4	Dozer
11 MAR 76	0.1	Truck Driver (in mine pit)
12 MAR 76	0.2	Truck Driver (in mine pit)
15 MAR 76	0.5	Front-End Loader
8 NOV 76	0.2	Trailor
17 NOV 76	0.2	Trailor
19 NOV 76	0.8	Scraper (working in till, not shale)
22 NOV 76	0.7	Scraper (working in till, not shale)

Dry, windy periods are most conducive to high particulate concentrations. Distributions of particle sizes were observed to closely resemble the log-normal distribution. Periods of abnormally high concentrations result in conditions which would increase the amount of inhaled particulate matter deposited in in the nasal canal, trachea and primary bronchi, and alveoli. Although there were no violations of present MESA health standards for mining personnel operating within the site boundaries, there were repeated violations in state primary and secondary ambient standards. Violations can be prevented by reducing source emissions. Because the largest single source emission is associated with hauling operations on unpaved surfaces, dust control on the haul roads would likely prevent violations.

V. Recommendations

A. Dust Control

Dust emissions caused by the strip mining of coal in Iowa can be easily controlled by properly treating haul roads traversed at high speeds by heavy equipment. Water and (or) commercially available chemicals applied at appropriate times would eliminate most dust problems from the mining environment. This could be achieved by using a watering truck, sprinkler systems or fitting a gravity-feed, slow-release watering device on at least one vehicle on each haul road circuit. The latter solution would eliminate the need for additional personnel or vehicles for achieving the desired effect.

B. Air-Quality Monitoring

An ambient air-quality-sampling network capable of monitoring detrimental effects of the mining operation should consist of at least three standard high-volume air samplers, two particle-size impactors (e.g.. Anderson 2000 or Cascade Impactor), electronic weather station modified for all-weather use, at least four 1500-watt AC electrical generators for powering samplers, and on-site personnel with at least one-half time devoted to air-quality monitoring and analysis.

A complete documentation of air-quality conditions could be achieved by taking successive one-hour high-volume samples in the downwind and upwind sectors during periods of mining activity and 24-hour samples at other times and in other sectors. Particle-sizing impactors could be deployed on an intermittent basis to obtain information on size distributions under various meteorological conditions and at various locations with respect to the source.

This monitoring network and procedure would provide (1) guidance for activation of dust-suppression measures, (2) assessment of the effects of such measures, and (3) supporting evidence for use in the event of litigation over air-quality degradation.

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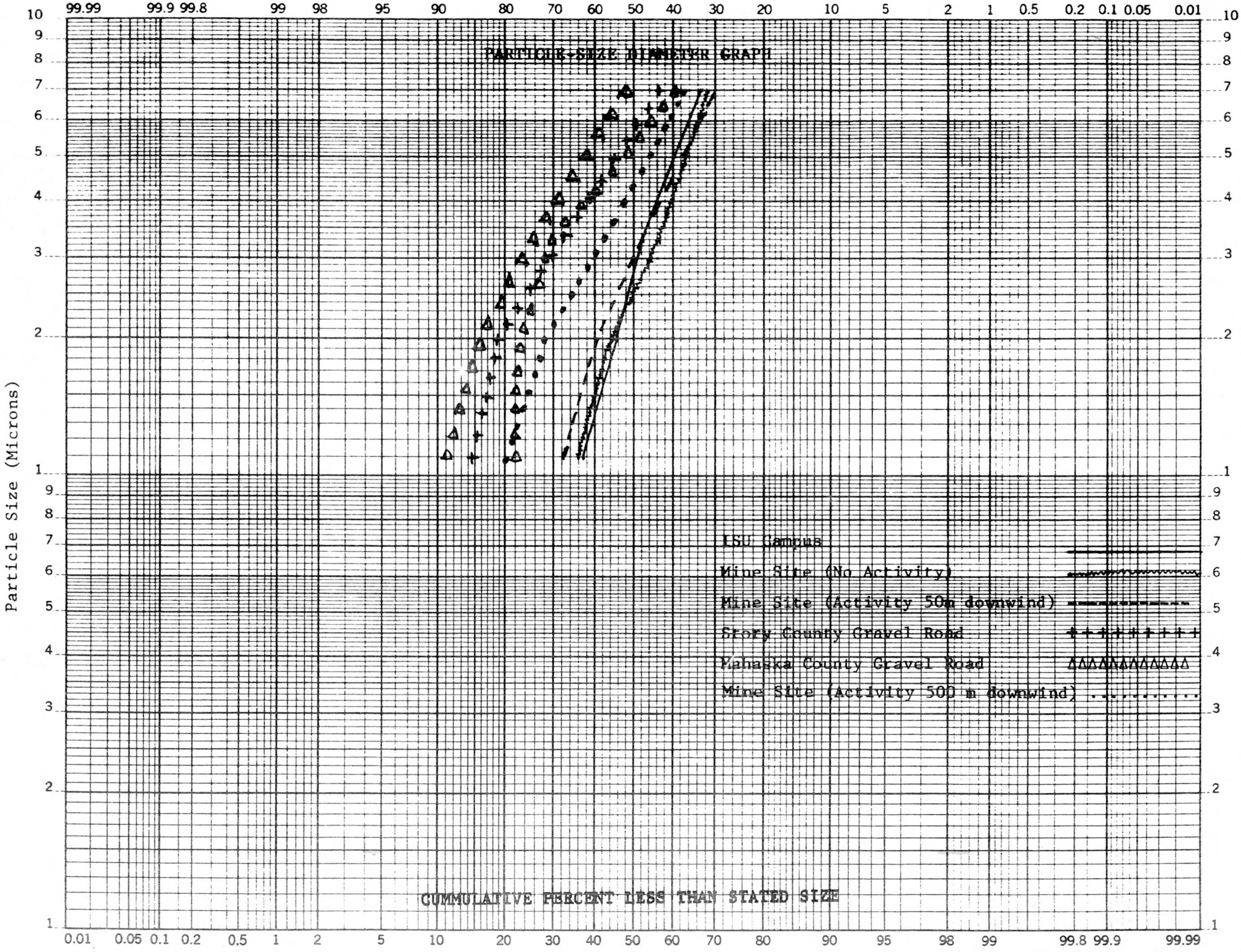
APPENDIX A

PARTICLE-SIZE DIAMETER GRAPH

IOWA COAL PROJECT SUSPENDED-PARTICULATE SIZING DATA


PARTICLE-SIZE DIAMETER GRAPH
Particle Size (Microns)
CUMMULATIVE PERCENT LESS THAN STATED SIZE
ISU Campus
Mine Site (No Activity)
Mine Site (Activity 50m downwind)
Story County Gravel Road
Mahaska County Gravel Road
Mine Site (Activity 500 m downwind)

IOWA COAL PROJECT

Suspended-Particulate Sizing Data

Location (Date)	Size Range (Microns)	Percent in Size Range	Cumulative Percent Less Than Size Range
ISU Campus	<1.1μ	36.82	0.00
No Activity[a]	1.1μ-2.0μ	8.38	36.82
(23 Aug 76)	2.0μ-3.3μ	7.44	45.20
	3.3μ-7.0μ	14.15	52.64
	>7.0μ	33.21	66.79
Mine Site -	<1.1μ	36.06	0.00
No Activity	1.1μ-2.0μ	8.55	36.06
(18 SEP 76)	2.0μ-3.3μ	11.90	44.61
	3.3μ-7.0μ	11.52	56.51
	>7.0μ	31.95	68.03
Mine Site with	<1.1μ	32.25	0.00
Activity at 50m	1.1μ-2.0μ	6.99	32.25
downwind	2.0μ-3.3μ	12.25	39.24
(18 SEP 76)	3.3μ-7.0μ	17.63	51.49
	>7.0μ	30.87	69.12
Mine Site with	<1.1μ	21.51	0.00
Activity at	1.1μ-2.0μ	6.39	21.51
500m downwind	2.0μ-3.3μ	13.21	27.90
(11 SEP 76)	3.3μ-7.0μ	21.55	41.11
	>7.0μ	37.34	62.66
Story County	<1.1μ	14.40	0.00
Gravel Road	1.1μ-2.0μ	4.41	14.40
(31 AUG 76)	2.0μ-3.3μ	13.10	18.81
	3.3μ-7.0μ	24.77	31.91
	>7.0μ	43.32	56.68
Mahaska County	<1.1μ	20.90	0.00
Gravel Road	1.1μ-2.0μ	1.49	20.90
(27 AUG 76)	2.0μ-3.3μ	7.46	22.39
	3.3μ-7.0μ	31.34	29.85
	>7.0μ	38.81	61.19
Mahaska County	<1.1μ	11.03	0.00
Gravel Road	1.1μ-2.0μ	4.59	11.03
(11 SEP 76)	2.0μ-3.3μ	10.11	15.62
	3.3μ-7.0μ	22.31	25.73
	>7.0μ	51.92	48.04

[a] Air-Pollution Advisories were in effect for part of the sampling period.

APPENDIX B

STATISTICAL DEFINITIONS

Statistical Definitions

Arithmetic Mean:

$$\bar{X} = \frac{\Sigma X}{N}$$

Standard Deviation:

$$S = \left[\frac{\Sigma (X - \bar{X})^2}{N-1} \right]^{\frac{1}{2}}$$

Geometric Mean:

$$\bar{X}_g = \mathrm{EXP} \left[\frac{\Sigma (\ell n X)}{N} \right]$$

Geometric Standard Deviation:

$$S_g = \left[\frac{\Sigma (\ell n X - \ell n \bar{X}_g)^2}{N - 1} \right]^{\frac{1}{2}}$$

APPENDIX C

SUMMARY OF HOURLY SURFACE OBSERVATIONS - DES MOINES, IOWA

[a] U.S. Department of Comerce, Decennial Census of United States Climate - Summary of Hourly Observations, Des Moines, Iowa, 1963.

DES MOINES, IOWA
Municipal AP

JANUARY
7440 Obs.

A TEMPERATURE AND WIND SPEED–RELATIVE HUMIDITY OCCURRENCES:

WIND	0-4 M.P.H.						5-14 M.P.H.						15-24 M.P.H.						25 M.P.H. AND OVER						TOTAL OBS
REL. HUMID. / TEMP °F	UNDER 30	30-49	50-69	70-79	80-89	90-100	UNDER 30	30-49	50-69	70-79	80-89	90-100	UNDER 30	30-49	50-69	70-79	80-89	90-100	UNDER 30	30-49	50-69	70-79	80-89	90-100	
59/ 55							1	2						4						4					11
54/ 50		1						9	4					8	5	3	1	3		1		1			36
49/ 45			4			6		14	11	4	1	12		3	8	3		4		2					72
44/ 40		1	11	1	1	6		16	59	27	9	27		11	38	5	1	3		1	6		2		225
39/ 35		1	5	23	13	21		6	85	114	88	88		7	67	44	31	26			7	4	1	2	633
34/ 30			7	12	16	34		5	113	164	195	219		3	53	62	55	49			8	4	5	1	1005
29/ 25		2	2	21	27	25		9	80	191	220	202		3	47	79	135	58			6	11	5	3	1126
24/ 20			7	13	22	34		5	81	145	250	206			43	89	114	61			10	11	12		1103
19/ 15		3	6	5	16	20		9	83	125	198	102		5	51	106	69	19			6	9	11	2	845
14/ 10		1	5	5	16	13		11	98	145	148	55		4	68	76	70	8			27	9	16		775
09/ 05		1	12	7	17	5	1	26	109	104	163	6		15	64	66	45				24	12	9		686
04/ 00			5	6	17			7	68	104	105			16	76	33	32				10	9	7		495
-01/-05			4	3	10			19	53	38	60			14	49	8	15				5	1	3		282
-06/-10			2	1	1			10	35	9	19			3	20	2	3				1				106
-11/-15			1	2				6	6	15				1	6										37
-16/-20				1						2															3
TOTAL		10	71	100	156	164	2	154	885	1187	1456	917		97	595	576	571	231		8	110	71	71	8	7440

B PERCENTAGE FREQUENCIES OF WIND DIRECTION AND SPEED:

DIRECTION	HOURLY OBSERVATIONS OF WIND SPEED (IN MILES PER HOUR) 0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	47 & OVER	TOTAL	AV. SPEED
N	.1	1.1	2.7	3.0	1.2	.3	.1			8.4	12.4
NNE	.1	1.0	1.8	1.9	.6	.1	+			5.4	12.5
NE	.2	.9	1.6	1.4	.3	+				4.4	11.4
ENE	.1	1.0	.8	.3						2.3	8.0
E	.2	1.3	1.0	.3	+					2.8	8.1
ESE	.1	1.0	1.9	.8	.1					3.9	9.7
SE	.2	1.5	3.6	1.6	.1					7.0	10.0
SSE	.2	1.4	2.6	1.9	.1	+				6.2	10.5
S	.1	1.4	3.2	2.3	.2	+				7.3	11.1
SSW	.1	.7	1.6	1.5	.6	.1				4.5	12.5
SW	.2	1.1	2.3	1.3	.3	.1	+			5.4	11.1
WSW	.1	1.0	1.9	1.1	.2	+				4.3	10.5
W	.2	1.4	1.8	1.2	.4	.2	+			5.2	11.4
WNW	.1	1.3	2.7	2.6	1.1	.7	.2	+		8.7	14.3
NW	.1	1.2	3.2	4.4	2.9	.8	.1			12.7	15.3
NNW	.1	1.0	2.5	3.6	2.3	.7	.1			10.3	15.3
CALM	1.3									1.3	
TOTAL	3.4	18.2	35.3	29.1	10.4	3.1	.5	+		100	12.1

C OCCURRENCES OF PRECIPITATION AMOUNTS:

INTENSITIES	FREQUENCY OF OCCURRENCE FOR EACH HOUR OF THE DAY — A.M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	NOON	P.M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	MID.	NO. OF DAYS WITH
TRACE	35	34	38	41	46	43	40	43	45	48	52	52	50	55	50	42	37	41	27	34	36	40	40	36	92
.01 IN	7	5	9	8	7	7	10	8	8	7	10	6	9	3	6	6	9	7	15	9	16	7	6	5	15
.02 TO .09 IN	6	6	8	8	7	9	9	6	7	11	7	5	4	6	7	5	5	8	6	10	2	4	5	6	32
.10 TO .24 IN	1	2	1	1				3	1	1		1				1	1				1	2			16
.25 TO .49 IN														1	1	1	1						1	1	7
.50 TO .99 IN																									2
1.00 TO 1.99 IN																									0
2.00 IN AND OVER																									1
TOTAL	49	47	56	58	60	59	59	60	61	67	69	64	63	65	64	55	53	56	48	53	55	53	52	48	165

D PERCENTAGE FREQUENCIES OF CEILING–VISIBILITY:

VISIBILITY (MILES)	CEILING (FEET) 0	100-200	300-400	500-900	1000-1900	2000-2900	3000-4900	5000-9500	OVER 9500	TOT
0 TO 1/8	.6	.3		+	+				+	.9
3/16 TO 3/8	.2	.5	+	+					+	.7
1/2 TO 3/4	.2	.6	.4	.4	.1		+		.1	1.9
1 TO 2 1/2		.8	1.6	2.5	1.8	.6	.4	.2	.8	8.7
3 TO 6		.1	.6	3.0	3.0	1.0	1.3	1.2	4.9	15.1
7 TO 15			+	1.2	6.1	3.7	3.1	6.0	52.7	72.7
20 TO 30										
35 OR MORE										
TOTAL	.9	2.2	2.6	7.1	11.0	5.3	4.8	7.4	58.6	100

E PERCENTAGE FREQUENCIES OF SKY COVER, WIND, AND RELATIVE HUMIDITY:

HOUR OF DAY	CLOUDS SCALE 0-10: 0-3	4-7	8-10	WIND SPEED (M.P.H.): 0-3	4-12	13-24	25 & OVER	RELATIVE HUMIDITY (%): 0-29	30-49	50-69	70-79	80-89	90-100
00	36	7	57	3	54	40	3		1	15	28	36	20
01	37	9	53	4	58	36	3		1	15	26	36	22
02	39	9	51	2	57	38	3		1	16	26	34	23
03	41	7	52	4	58	35	2		1	16	25	34	25
04	37	8	55	4	57	36	2		1	15	23	35	25
05	38	9	53	3	56	37	3		1	15	24	35	25
06	38	7	55	3	56	38	3		2	14	22	39	23
07	32	9	59	4	57	36	3		2	12	22	40	24
08	30	5	65	4	58	36	2		2	14	22	40	22
09	25	10	65	5	51	38	5		2	17	21	42	17
10	27	10	62	3	55	37	6		2	23	25	34	16
11	30	8	62	4	49	41	7		4	29	26	25	15
12	27	10	62	3	46	45	5		6	34	25	22	14
13	26	11	63	3	44	48	6		8	37	24	20	10
14	27	9	64	5	40	48	7	+	10	39	23	16	9
15	27	10	63	3	43	49	6		10	40	25	15	9
16	28	10	63	3	46	46	5		8	37	28	17	10
17	29	10	61	5	55	37	2		6	31	30	22	11
18	31	10	59	3	59	36	3	+	5	27	27	27	14
19	34	10	57	3	57	37	3		4	21	33	25	17
20	35	10	55	3	58	36	3		3	20	29	29	18
21	38	10	52	3	55	39	2		3	17	30	32	19
22	38	9	53	4	56	38	2		2	16	31	32	20
23	35	10	54	3	56	39	2		1	15	29	36	19
AVG	33	9	58	3	53	39	4	+	4	22	26	30	18

DES MOINES, IOWA
Municipal AP

FEBRUARY
6792 Obs.

A TEMPERATURE AND WIND SPEED–RELATIVE HUMIDITY OCCURRENCES:

WIND	0-4 M.P.H.						5-14 M.P.H.						15-24 M.P.H.						25 M.P.H. AND OVER						TOTAL OBS
REL. HUMID. / TEMP °F	UNDER 30	30-49	50-69	70-79	80-89	90-100	UNDER 30	30-49	50-69	70-79	80-89	90-100	UNDER 30	30-49	50-69	70-79	80-89	90-100	UNDER 30	30-49	50-69	70-79	80-89	90-100	
69/ 65									1						2										3
64/ 60									3					3	7	2									15
59/ 55								8	1	2	1		7	14	6	1	3								43
54/ 50		1	3					17	14	6	2	10	3	21	20	1	2	4		3	9				116
49/ 45		1	6			1	3	15	61	10	10	31	2	19	42	6	6	21		3	6		1	1	245
44/ 40			11	2	3	8	2	17	90	65	27	38	2	21	72	30	9	20		9	6	1	1	6	440
39/ 35			9	6	9	13		18	127	106	146	137		14	83	91	70	41		5	5	8	9	2	899
34/ 30			4	4	15	51		19	133	162	247	338		16	59	107	124	113			2	15	5	2	1416
29/ 25			2	15	23	28		7	77	124	241	194		10	50	56	117	78			6	3	1	6	1038
24/ 20			5		18	6		3	95	87	171	133		6	39	62	70	41			11	12	11	3	773
19/ 15			6	12	7	2		4	82	96	118	35		5	43	53	42	6			14	12	14		551
14/ 10			7	7	10	8		2	56	61	115	19		7	39	42	34				12	11	5		435
09/ 05		2	3	4	7	4		7	73	46	56	1		1	44	34	11				11	4	2		310
04/ 00			5	5	5	6			52	58	52	2			22	26	4				3	1			241
-01/-05			1		4	2		2	30	37	42	1		2	15	10					11	8			165
-06/-10			3	2				1	14	10	9			3	4	17						1			64
-11/-15				1				1	6	10				3	2	4									27
-16/-20									2	9															11
TOTAL		4	65	58	101	129	5	121	917	889	1237	939	14	145	549	542	492	324		20	96	76	49	20	6792

B PERCENTAGE FREQUENCIES OF WIND DIRECTION AND SPEED:

DIRECTION	0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	47 OVER	TOTAL	AV SPEED
	HOURLY OBSERVATIONS OF WIND SPEED (IN MILES PER HOUR)										
N	.1	.7	1.9	2.9	1.2	.3	+			7.1	14.4
NNE	.1	.7	1.8	2.8	1.2	.3	+			6.9	14.4
NE	.1	.7	2.0	1.5	.1	.1				4.5	11.3
ENE	+	.7	1.5	1.0	.2	.1				3.5	11.6
E	.1	.8	1.6	1.2	.3					3.9	11.6
ESE	+	.8	2.7	1.6	.4	+				5.4	11.6
SE	.1	1.1	3.1	1.7	.1					6.1	10.7
SSE	.1	.9	2.1	1.2	.2					4.6	10.7
S	.1	.7	2.4	1.8	.4					5.4	11.8
SSW	.1	.7	2.3	1.9	.4	+				5.4	11.8
SW	.1	1.0	2.1	1.1	.5	.2	.1	+		5.1	12.3
WSW	.1	1.0	1.8	1.1	.5	.1	+	+		4.7	12.1
W	.1	1.3	2.0	1.2	.4	.1	.1			5.3	11.7
WNW	.1	1.3	3.0	3.3	1.7	.5	.1			9.9	14.4
NW	.1	1.3	3.4	4.3	2.1	.8	.2			12.2	14.9
NNW	.2	.7	2.6	2.9	1.6	.3	.2	+		8.5	14.5
CALM	1.3									1.3	
TOTAL	2.9	14.3	36.2	31.3	11.3	2.9	.9	.1		100	12.7

C OCCURRENCES OF PRECIPITATION AMOUNTS:

INTENSITIES	A.M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	NOON	P.M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	MID	NO. OF DAYS WITH
	FREQUENCY OF OCCURRENCE FOR EACH HOUR OF THE DAY																								
TRACE	30	26	27	38	37	40	46	40	45	46	38	37	42	40	32	30	34	30	26	30	30	36	31	32	71
.01 IN	14	9	11	9	11	9	4	4	6	7	7	7	5	6	8	7	7	8	11	9	10	10	10	13	8
.02 TO .09 IN	10	16	16	8	9	8	8	10	7	8	8	5	4	4	5	7	8	7	7	8	10	5	11	9	35
.10 TO .24 IN		2		1							1	1	1	3	3	1	3	1	1			3	1	1	15
.25 TO .49 IN																									14
.50 TO .99 IN																									3
1.00 TO 1.99 IN																									1
2.00 IN AND OVER																									
TOTAL	54	53	54	56	57	57	58	54	58	61	54	50	52	53	48	45	52	46	45	47	50	54	53	55	147

D PERCENTAGE FREQUENCIES OF CEILING–VISIBILITY:

VISIBILITY (MILES)	CEILING (FEET) 0	100-200	300-400	500-900	1000-1900	2000-2900	3000-4900	5000-9500	OVER 9500	TOT
0 TO 1/8	.7	.4							.1	1.2
3/16 TO 3/8	.3	.7	.1		+				+	1.2
1/2 TO 3/4	.1	1.0	.8	.2	.1	+			+	2.3
1 TO 2 1/2		.7	2.0	3.2	1.5	.3	.1	+	.3	8.2
3 TO 6		+	.7	3.5	2.8	1.0	.8	.9	3.5	13.2
7 TO 15			+	.8	4.7	4.5	3.8	5.3	54.0	73.9
20 TO 30										
35 OR MORE										
TOTAL	1.1	2.9	3.7	7.7	9.1	5.9	4.8	6.3	58.5	100

E PERCENTAGE FREQUENCIES OF SKY COVER, WIND, AND RELATIVE HUMIDITY:

HOUR OF DAY	CLOUDS SCALE 0-10: 0-3	4-7	8-10	WIND SPEED (M.P.H.): 0-3	4-12	13-24	25-& OVER	RELATIVE HUMIDITY (%): 0-29	30-49	50-69	70-79	80-89	90-100
00	40	7	53	2	58	36	4		1	13	25	36	24
01	41	10	49	2	55	40	2		1	14	24	37	24
02	41	8	51	5	55	38	3		1	13	21	40	25
03	40	8	52	4	58	36	2		1	13	24	37	25
04	39	10	51	4	56	37	3		1	11	22	37	29
05	41	8	51	4	55	39	2		1	13	20	38	28
06	39	10	51	4	55	39	1		1	13	17	37	32
07	35	8	57	6	52	40	2			12	21	37	30
08	32	12	56	6	48	43	3		1	14	24	33	29
09	32	9	59	5	43	47	4		1	20	27	28	23
10	34	8	59	4	42	49	5		2	30	26	24	18
11	31	12	57	3	45	47	6		6	35	26	18	15
12	34	10	56	1	45	46	7	+	8	39	24	14	14
13	35	10	54	2	43	48	7	+	11	40	19	16	13
14	32	12	56	2	40	52	7	2	13	39	18	17	11
15	32	11	57	2	40	52	6	2	13	40	17	16	12
16	32	11	57	1	41	53	4	2	13	39	20	14	12
17	36	9	55	1	47	49	2	1	9	38	23	14	15
18	37	11	52	1	57	39	4		7	34	27	17	16
19	40	10	49	2	53	41	3		5	27	26	24	18
20	42	10	47	2	55	39	4		4	21	27	29	19
21	41	10	49	2	54	41	3		2	19	28	30	21
22	43	9	48	3	55	37	4		1	20	22	35	22
23	43	10	47	3	58	36	3		1	19	22	36	23
AVG	37	10	53	3	51	43	4	+	4	24	23	28	21

DES MOINES, IOWA
Municipal AP

MARCH
7440 Obs.

A TEMPERATURE AND WIND SPEED–RELATIVE HUMIDITY OCCURRENCES:

WIND	0-4 M.P.H.						5-14 M.P.H.						15-24 M.P.H.						25 M.P.H. AND OVER						TOTAL OBS.
REL. HUMID. / TEMP °F	UNDER 30	30-49	50-69	70-79	80-89	90-100%	UNDER 30	30-49	50-69	70-79	80-89	90-100%	UNDER 30	30-49	50-69	70-79	80-89	90-100%	UNDER 30	30-49	50-69	70-79	80-89	90-100%	
79/ 75							1						1												2
74/ 70							1						7	4	3				2	1	3				21
69/ 65		1						8					18	10	5					1	4				47
64/ 60		2					3	13		3	1		19	34	5	7	2		1	4		2			96
59/ 55		3			1		5	28	24	3	6	4	22	59	23	10	4		5	7	5				209
54/ 50		6	1		1	1	1	51	56	16	15	12	6	68	49	9	2	4	4	14	8	1	1		326
49/ 45		10	3	1	3	3	10	93	95	26	30	45	11	82	73	12	22	4	1	10	4	2	1	1	542
44/ 40		1	15	3			6	131	169	60	59	90	3	58	92	33	39	50		4	17	7	9	1	847
39/ 35		5	19	1	4	9		53	253	118	91	60		15	139	74	68	121		3	23	19	8	14	1097
34/ 30			19	12	21	34		22	240	232	171	173		11	103	157	133	129			29	16	15	32	1549
29/ 25		1	12	9	29	25		8	131	149	208	110		12	67	89	104	72		2	21	26	13	19	1107
24/ 20			5	8	16	17		6	80	84	80	49		10	77	73	78	18		2	19	28	35	11	696
19/ 15			2	8	8			1	61	88	56	31		4	44	57	43	7			21	17	7		455
14/ 10		1		5	3	1			27	47	31	6		1	43	26	17	4			16	9	1		238
09/ 05			4	1	5	2			25	21	22	5			18	14	9				3	4	2		135
04/ 00			2	3	3				6	3	6	1			11	7									42
-01/-05			1	1						9						3	1								15
-06/-10				1						3						5									9
-11/-15										7															7
TOTAL		30	83	53	94	92	27	414	1167	869	776	586	87	368	752	576	522	409	13	48	173	131	92	78	7440

B PERCENTAGE FREQUENCIES OF WIND DIRECTION AND SPEED:

DIRECTION	HOURLY OBSERVATIONS OF WIND SPEED (IN MILES PER HOUR) 0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	47 & OVER	TOTAL	AV. SPEED
N	.1	.5	1.7	2.9	2.2	.8	.1			8.4	16.4
NNE	.1	.5	1.5	2.5	1.0	.3	+			6.0	14.6
NE	.2	.7	1.7	1.8	.7	.1				5.2	12.8
ENE	.1	.9	2.0	1.9	.7	.1				5.6	12.5
E	+	1.3	2.3	2.0	.4	.2				6.2	12.0
ESE	.1	1.2	3.5	2.4	.5	.2	.1			8.1	12.4
SE	.1	1.1	3.0	2.4	.5	.1				7.2	11.9
SSE	.1	.8	2.3	2.0	.3	.1				5.5	12.0
S	.2	.8	1.8	2.0	.6	.1	.1			5.5	12.8
SSW	+	.4	1.3	1.5	.5	.1		+		3.8	13.8
SW	.1	.5	.7	1.1	.3	+	+	+		2.7	13.0
WSW	.1	.6	.9	.9	.5	.2	+			3.2	13.8
W	.1	.9	1.5	1.3	.5	.4	.1			4.9	13.7
WNW	.1	.8	2.2	2.8	1.4	1.2	.6	.1		9.2	17.0
NW	.1	.8	1.9	3.6	2.4	1.3	.1			10.2	16.9
NNW	.1	.7	1.2	2.5	2.0	.6	.2	+		7.2	16.7
CALM	1.1									1.1	
TOTAL	2.5	12.6	29.4	33.6	14.7	5.7	1.4	.1		100	14.1

C OCCURRENCES OF PRECIPITATION AMOUNTS:

INTENSITIES	A.M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	NOON	P.M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	MID	NO. OF DAYS WITH
TRACE	33	40	36	47	52	42	44	41	45	42	43	43	39	41	31	40	41	32	39	39	45	38	40	37	66
.01 IN	11	6	14	8	10	15	9	12	6	10	8	6	8	6	6	11	7	14	12	14	10	6	11	9	15
.02 TO .09 IN	13	10	13	13	12	12	12	13	17	15	12	12	11	12	19	15	17	18	14	16	12	13	9	12	33
.10 TO .24 IN	3	2	1	3	2	2	2	1			2	1	1	1			1	3	1	3	5	4	4	3	24
.25 TO .49 IN		1	1																			1			16
.50 TO .99 IN																								1	14
1.00 TO 1.99 IN																									1
2.00 IN AND OVER																									
TOTAL	60	59	65	71	76	71	67	67	68	67	65	62	59	60	56	66	66	67	66	72	72	62	64	62	169

D PERCENTAGE FREQUENCIES OF CEILING–VISIBILITY:

VISIBILITY (MILES)	CEILING (FEET) 0	100-200	300-400	500-900	1000-1900	2000-2900	3000-4900	5000-9500	OVER 9500	TOT
0 TO 1/8	.2	.1	+		+	+			.1	.5
3/16 TO 3/8	.1	.2	+	+		+			.1	.5
1/2 TO 3/4		.2	.5	.9	.1	+			.1	1.8
1 TO 2 1/2		.3	1.4	2.7	1.5	.2	.2	.1	.4	6.8
3 TO 6		+	.5	2.4	3.0	.8	.7	1.0	2.5	10.9
7 TO 15			.1	1.3	5.8	5.5	6.7	9.1	51.2	79.5
20 TO 30										
35 OR MORE										
TOTAL	.3	.9	2.6	7.3	10.4	6.5	7.6	10.2	54.3	100

E PERCENTAGE FREQUENCIES OF SKY COVER, WIND, AND RELATIVE HUMIDITY:

HOUR OF DAY	CLOUDS SCALE 0-10: 0-3	4-7	8-10	WIND SPEED (M.P.H.): 0-3	4-12	13-24	25-& OVER	RELATIVE HUMIDITY (%): 0-29	30-49	50-69	70-79	80-89	90-100
00	39	9	52	4	52	40	5		3	27	28	22	20
01	41	6	53	5	46	45	4		3	24	28	27	19
02	38	9	53	2	51	43	4		3	19	29	29	2[illegible]
03	39	8	53	4	49	44	4		2	17	29	31	21
04	39	8	54	5	45	45	5		2	16	28	32	22
05	39	8	53	3	47	46	4		2	15	27	33	23
06	34	8	58	3	47	46	4		2	15	27	32	25
07	30	12	58	3	46	45	6		1	18	27	31	23
08	27	11	62	2	43	49	6		2	24	33	23	19
09	23	13	64	1	39	52	8		6	38	24	16	15
10	25	14	61	2	34	55	9	+	15	41	16	15	12
11	28	12	60	2	33	54	11	+	21	41	17	13	8
12	28	11	62	2	29	55	14	2	25	41	13	11	9
13	28	11	61	3	29	55	14	5	26	36	13	13	8
14	22	15	63	3	28	55	15	8	28	33	14	8	9
15	22	12	66	2	30	55	14	7	29	35	10	11	9
16	24	10	65	2	31	56	12	7	27	33	14	10	10
17	23	10	67	2	34	54	11	5	23	36	14	11	11
18	26	9	65	1	44	50	5	3	20	37	17	10	13
19	31	10	59	2	51	44	3	1	15	35	21	16	13
20	30	11	59	3	49	43	5	1	10	35	21	19	14
21	32	10	57	2	50	44	4	+	6	32	24	21	16
22	36	9	55	2	49	44	5	1	5	30	26	22	17
23	38	8	54	2	52	42	5	+	4	25	26	25	20
AVG	31	10	59	2	42	48	7	2	12	29	22	20	16

A TEMPERATURE AND WIND SPEED—RELATIVE HUMIDITY OCCURRENCES:

WIND	0-4 M.P.H.						5-14 M.P.H.						15-24 M.P.H.						25 M.P.H. AND OVER						TOTAL OBS
REL. HUMID. / TEMP. (°F)	UNDER 30	30-49%	50-69%	70-79%	80-89%	90-100%	UNDER 30	30-49%	50-69%	70-79%	80-89%	90-100%	UNDER 30	30-49%	50-69%	70-79%	80-89%	90-100%	UNDER 30	30-49%	50-69%	70-79%	80-89%	90-100%	
89/ 85							4							3						5					12
84/ 80		2					12	8	1				3	23	11				1	6	2				69
79/ 75		1					27	24	14	1			19	34	41	2	1		6	6	2				178
74/ 70	2	4					32	53	27	11	1		47	52	52	23			7	10	8	3			332
69/ 65	7	3	1		1	1	30	80	52	31	30	4	45	63	53	22	22	2	14	10		2	2		475
64/ 60	5	4	9	1	2	1	23	108	96	28	35	43	38	92	66	23	23	13	5	15	4	1	1	1	637
59/ 55	2	9	11	1	6	9	31	131	108	49	45	103	34	83	56	45	40	31	6	21	8	4	5	6	844
54/ 50	1	8	10	9	4	13	37	147	164	66	65	85	27	84	57	17	47	63	5	30	16	4	6	2	967
49/ 45	2	10	21	1	4	5	7	151	188	74	86	99	20	74	92	62	66	89	3	27	11	5	10	7	1114
44/ 40		6	16	5	3	3	4	66	189	81	59	47	1	45	117	39	61	80		16	31	10	4	11	894
39/ 35		2	6	12	8	12		18	115	99	91	78		17	115	60	58	56		10	37	16	33	23	866
34/ 30		2	10	5	9	3		6	59	53	95	68		21	72	38	58	86	1		14	2	3	11	616
29/ 25			2	5		1		5	28	24	11	8		9	34	15	1			1	2	5			151
24/ 20									8	13	3			2	11	1									38
19/ 15									1	1					5										7
TOTAL	19	51	86	39	37	48	207	797	1050	531	521	535	234	602	782	347	377	420	48	157	135	52	64	61	7200

B PERCENTAGE FREQUENCIES OF WIND DIRECTION AND SPEED:

DIRECTION	HOURLY OBSERVATIONS OF WIND SPEED (IN MILES PER HOUR) 0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	47 & OVER	TOTAL	AV. SPEED
N	.1	.6	1.9	3.3	1.6	.4	+			8.0	15.1
NNE	.1	.6	1.4	3.0	.8	.1				6.1	13.9
NE	.1	.6	1.7	2.3	.3	+				5.0	12.5
ENE	.1	.6	1.5	1.8	.3	+				4.2	12.3
E	+	.8	1.9	1.9	.6	.1				5.4	12.9
ESE	+	.9	2.3	2.1	.8	.2	+			6.3	13.1
SE	.1	.9	2.8	2.8	1.1	.2				8.0	13.2
SSE	+	.8	1.9	2.2	.8	.2				6.0	13.3
S	+	1.2	2.5	2.4	.8	.2	+			7.2	13.0
SSW	+	.5	1.5	2.3	1.1	.3	+			5.7	14.8
SW	.1	.6	1.5	1.2	.7	.2	.1			4.4	14.1
WSW	.1	.5	1.2	.8	.7	.1	.1	+		3.4	14.2
W	+	.9	1.5	1.2	.4	.1	.1			4.3	12.8
WNW	.1	.9	1.9	1.7	1.5	.9	.3	+		7.4	16.4
NW	.2	.9	1.7	2.5	2.6	1.6	.3	.2	+	10.0	18.1
NNW	.1	.5	1.4	2.7	2.0	.8	.3	.1		7.8	17.5
CALM	.8									.8	
TOTAL	1.9	11.8	28.6	34.4	16.2	5.5	1.3	.3	+	100	14.4

C OCCURRENCES OF PRECIPITATION AMOUNTS:

INTENSITIES	FREQUENCY OF OCCURRENCE FOR EACH HOUR OF THE DAY — A.M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	NOON	P.M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	MID.	NO. OF DAYS WITH
TRACE	20	22	23	27	26	33	29	32	34	31	28	27	24	22	23	25	36	28	24	20	26	27	25	25	39
.01 IN.	7	10	9	8	9	5	6	10	8	6	7	8	3	4	8	9	6	3	7	5	12	7	8	7	10
.02 TO .09 IN.	15	15	18	18	18	19	17	13	15	16	17	15	16	15	16	12	9	10	14	15	11	14	13	13	37
.10 TO .24 IN.	2	3	1	2	6	3	2		2	3	3	2	1			3	3	2	2	1		3	1		24
.25 TO .49 IN.			1	1													1	1	1	1			1	1	23
.50 TO .99 IN.														1	1			1							11
1.00 TO 1.99 IN.																									5
2.00 IN. AND OVER																									
TOTAL	44	50	52	56	59	60	54	55	59	56	55	52	44	42	48	49	55	45	48	42	49	51	48	46	149

D PERCENTAGE FREQUENCIES OF CEILING–VISIBILITY:

VISIBILITY (MILES)	CEILING (FEET) 0	100-200	300-400	500-900	1000-1900	2000-2900	3000-4900	5000-9500	OVER 9500	TOT
0 TO 1/8	+	+						+	.1	.1
3/16 TO 3/8	+	.1							+	.1
1/2 TO 3/4		.1	.1	+	+				+	.3
1 TO 2 1/2		.2	1.0	1.4	.2	.1	.1	.1	.1	3.1
3 TO 6			.4	3.5	1.5	.4	.6	.7	1.9	8.2
7 TO 15			.1	2.1	5.3	4.8	8.2	10.0	57.7	88.2
20 TO 30										
35 OR MORE										
TOTAL	.1	.3	1.6	6.8	7.0	5.3	8.9	10.8	59.2	100

E PERCENTAGE FREQUENCIES OF SKY COVER, WIND, AND RELATIVE HUMIDITY:

HOUR OF DAY	CLOUDS SCALE 0-10: 0-3	4-7	8-10	WIND SPEED (M.P.H.): 0-3	4-12	13-24	25 & OVER	RELATIVE HUMIDITY (%): 0-29	30-49	50-69	70-79	80-89	90-100
00	44	8	48	4	52	42	2	+	14	35	19	16	16
01	42	8	50	3	54	41	2		9	36	17	19	19
02	40	10	49	3	54	41	3		8	32	18	21	21
03	40	10	50	3	50	44	3		6	31	19	22	23
04	41	7	52	2	52	43	2		4	29	20	22	25
05	34	12	54	2	53	43	2		4	22	23	23	28
06	30	9	60	3	49	45	3		3	22	21	27	27
07	31	11	58	4	42	49	5		4	34	17	21	24
08	30	14	56	4	33	58	6	+	13	37	16	15	18
09	29	14	57	2	30	59	9	3	22	36	13	13	14
10	28	16	56	3	27	60	10	6	31	31	11	9	12
11	27	14	60	2	24	61	13	10	36	28	7	9	10
12	25	13	61	2	24	62	12	12	38	26	5	9	10
13	24	13	63	2	25	59	13	17	38	22	7	7	8
14	23	15	62	1	23	59	17	20	36	21	9	6	8
15	22	20	58	+	25	61	14	23	36	19	7	8	7
16	22	15	63	+	24	61	15	23	34	19	7	8	9
17	27	14	59	+	27	61	12	21	35	22	8	7	7
18	28	14	59	+	39	54	7	15	37	23	10	7	8
19	33	11	56	1	49	46	4	8	34	27	11	9	11
20	37	10	53	+	55	43	[illegible]	6	31	29	12	12	11
21	40	11	49	1	52	43	4	3	26	34	13	12	12
22	43	9	48	2	54	[illegible]	3	2	22	33	15	15	13
23	45	9	46	2	53	42	4	1	17	35	17	17	14
AVG	33	12	55	2	40	51	7	7	22	29	13	14	15

DES MOINES, IOWA
Municipal AP

MAY
7440 Obs.

A TEMPERATURE AND WIND SPEED—RELATIVE HUMIDITY OCCURRENCES:

WIND	0-4 M.P.H.						5-14 M.P.H.						15-24 M.P.H.						25 M.P.H. AND OVER						TOTAL OBS
REL. HUMID / TEMP °F	UNDER 30	30-49	50-69	70-79	80-89	90-100	UNDER 30	30-49	50-69	70-79	80-89	90-100	UNDER 30	30-49	50-69	70-79	80-89	90-100	UNDER 30	30-49	50-69	70-79	80-89	90-100	
94/ 90									1				4	2	2				1	2					12
89/ 85	1	2					11	11					5	26	7	1				8					72
84/ 80	1	4	1				13	75	19	6			9	55	47	6				9	7				252
79/ 75	3	7	9	2			32	116	114	21	7		26	85	100	32	3		5	16	10	3			591
74/ 70	9	3	7	14	4		35	163	123	65	65	14	28	122	93	46	30	4	4	15	8	4			856
69/ 65	6	16	9	6	6	15	32	172	179	128	111	94	16	92	91	54	44	26	3	16	4	1	3		1124
64/ 60	1	13	26	6	17	22	24	167	276	87	117	224	19	73	97	30	52	66	6	12	9	5	2	2	1353
59/ 55		12	24	17	7	16	11	89	272	146	102	211	16	57	111	52	54	66	2	1	14	5	4		1289
54/ 50		7	19	15	9	8	2	42	179	127	124	114	1	42	53	39	55	37	1	8	6	5	2	1	896
49/ 45			13	10	21	12		27	79	77	53	108		24	36	35	29	33		2	4			3	566
44/ 40			1	4	2	6		5	48	50	47	35		2	27	10	24	20		1	4		5	5	296
39/ 35				1				1	18	23	18	4			15	3	2	2			7	3	3	1	101
34/ 30										12	6				5	1	1				5	2			32
TOTAL	21	64	109	75	66	79	160	868	1308	742	650	804	124	580	684	309	294	254	22	90	78	28	19	12	7440

B PERCENTAGE FREQUENCIES OF WIND DIRECTION AND SPEED:

DIRECTION	HOURLY OBSERVATIONS OF WIND SPEED (IN MILES PER HOUR) 0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	47 & OVER	TOTAL	AV SPEED
N	.1	1.0	2.2	2.3	.6	.1		+		6.3	12.6
NNE	.1	.7	1.6	1.5	.6	+				4.6	12.4
NE	.1	.6	1.8	1.6	.3	+				4.3	11.9
ENE	.1	.8	1.8	1.1	.3	+				4.2	11.0
E	.1	1.0	2.2	1.5	.2					4.9	10.8
ESE	.1	1.3	2.7	2.1	.3					6.4	11.1
SE	.1	1.5	3.8	2.9	.5	+				9.0	11.4
SSE	.1	1.4	3.2	3.2	.7	.2	+			8.9	12.4
S	.1	1.8	3.4	3.5	.9	.2	+			9.9	12.4
SSW	+	.8	2.1	2.3	.9	.2	.1			6.5	13.7
SW	.1	.7	1.6	1.6	.8	.2	.1			5.2	13.4
WSW	+	.6	1.3	1.4	.5	.3	+	+		4.2	13.9
W	.1	1.1	1.5	1.0	.4	.1				4.3	11.5
WNW	.1	1.0	1.8	1.6	.8	.3	.2			5.8	13.7
NW	.2	1.2	2.8	2.2	1.4	.7	.3	+		8.8	14.7
NNW	.1	.7	1.9	2.2	1.0	.2	+			6.1	14.0
CALM	.9									.9	
TOTAL	2.5	16.3	35.6	31.9	10.4	2.6	.7	.1		100	12.5

C OCCURRENCES OF PRECIPITATION AMOUNTS:

INTENSITIES	FREQUENCY OF OCCURRENCE FOR EACH HOUR OF THE DAY — A.M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	NOON	P.M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	MID	NO. OF DAYS WITH
TRACE	25	24	20	30	27	26	21	23	18	21	21	20	28	22	26	18	26	21	18	17	26	21	25	23	65
.01 IN	3	3	8	2	6	2	7	5	4	3	7	3	10	9	4	5	3	3	6	5	2	4	5	2	7
.02 TO .09 IN	8	9	7	12	8	13	6	13	9	10	9	13	8	8	14	10	6	12	7	8	3	4	4	8	30
.10 TO .24 IN	4	7	5	4	5	4	5	3	7	6	6	5	2	4	1	5	5	1	4	3	1	2		3	14
.25 TO .49 IN	3		2	1		1	1		1	2	1	2	2			2	3		4	1	1	1		3	17
.50 TO .99 IN	1	1	1		1						1				1		1	2	1	1					21
1.00 TO 1.99 IN																1		1							10
2.00 IN AND OVER																									4
TOTAL	44	44	43	49	47	46	40	44	39	42	45	43	50	43	46	41	44	40	40	35	33	32	34	39	168

D PERCENTAGE FREQUENCIES OF CEILING–VISIBILITY:

VISIBILITY (MILES)	CEILING (FEET) 0	100-200	300-400	500-900	1000-1900	2000-2900	3000-4900	5000-9500	OVER 9500	TOT
0 TO 1/8	.1	+							.1	.2
3/16 TO 3/8		.1							+	.1
1/2 TO 3/4		.1	.1		+				.1	.2
1 TO 2 1/2		.1	.3	.3	.1	+	+		.1	1.0
3 TO 6			.6	2.0	1.1	.4	.6	.4	1.3	6.3
7 TO 15			.1	1.3	4.6	3.9	7.2	10.1	65.0	92.2
20 TO 30										
35 OR MORE										
TOTAL	.1	.3	1.0	3.6	5.8	4.3	7.8	10.5	66.5	100

E PERCENTAGE FREQUENCIES OF SKY COVER, WIND, AND RELATIVE HUMIDITY:

HOUR OF DAY	CLOUDS SCALE 0-10: 0-3	4-7	8-10	WIND SPEED (M.P.H.): 0-3	4-12	13-24	25 & OVER	RELATIVE HUMIDITY (%): 0-29	30-49	50-69	70-79	80-89	90-100
00	49	13	38	3	69	27	1	+	10	33	19	17	20
01	47	11	42	2	73	25	1		5	31	20	18	25
02	45	13	43	2	67	29	1		3	29	21	21	27
03	45	11	45	3	66	31	1		3	24	22	20	32
04	41	13	46	4	63	33	+		2	22	20	24	32
05	34	12	54	2	66	31	1		2	21	20	25	32
06	33	11	57	4	61	34	1		2	23	22	25	28
07	33	11	57	4	50	45	2		5	33	19	22	21
08	32	11	58	3	44	50	3	+	15	35	18	16	15
09	29	12	59	3	40	51	5	1	25	34	16	12	11
10	26	13	61	1	36	56	6	2	33	32	14	10	8
11	25	15	60	3	34	57	6	6	36	29	13	8	8
12	24	13	63	2	34	55	8	9	38	27	11	8	7
13	24	17	59	2	30	60	8	10	40	25	12	7	6
14	22	20	58	2	32	59	8	15	38	25	12	4	6
15	23	21	56	1	34	58	6	15	39	24	11	4	7
16	25	20	55	3	35	56	6	15	37	28	7	5	7
17	30	16	53	3	36	55	5	14	39	26	8	5	8
18	33	16	51	3	46	46	4	9	40	28	9	6	7
19	35	17	48	2	60	36	1	5	32	31	13	10	9
20	39	17	44	2	69	27	1	2	26	34	13	14	11
21	43	19	38	2	66	30	2	1	20	36	15	16	12
22	49	15	36	2	66	30	1	1	15	37	17	14	16
23	50	15	35	2	60	31	1	+	10	35	19	19	16
AVG	35	15	51	3	52	42	3	+	22	29	16	14	15

DES MOINES, IOWA
Municipal AP

JUNE
7200 Obs.

A TEMPERATURE AND WIND SPEED–RELATIVE HUMIDITY OCCURRENCES:

WIND	0-4 MPH						5-14 MPH						15-24 MPH						25 MPH AND OVER						TOTAL OBS.
REL. HUMID. / TEMP (°F)	UNDER 30	30-49%	50-69%	70-79%	80-89%	90-100%	UNDER 30	30-49%	50-69%	70-79%	80-89%	90-100%	UNDER 30	30-49%	50-69%	70-79%	80-89%	90-100%	UNDER 30	30-49%	50-69%	70-79%	80-89%	90-100%	
104/100								1																	1
99/ 95							1	4	9				1	20	2										37
94/ 90	3	4					19	52	32				13	42	57					1					223
89/ 85		6	6	1			12	90	112	10			7	77	118	3				7	6				455
84/ 80	3	10	7	3	2		16	149	248	69	17		4	101	161	36	3			5	9	2			845
79/ 75		12	20	10	12	5	12	199	251	194	91	14		67	112	73	34	5			8	2			1121
74/ 70		15	17	11	17	13		134	274	185	228	86	4	38	88	55	51	16	1	3	5	4	2		1247
69/ 65		3	22	22	17	52		78	261	179	211	306		27	54	45	41	50		1		2		1	1372
64/ 60		1	12	14	17	29		22	157	169	160	259		12	43	52	45	30		2	2	3		3	1032
59/ 55			7	12	9	13		2	65	84	130	128		2	28	41	20	42			1		1	1	586
54/ 50				1	10	8			20	37	48	36			10	17	13	22							222
49/ 45					2	3			1	12	14	17			1	3	3	1							57
44/ 40												2													2
TOTAL	6	51	91	74	86	123	60	731	1430	939	899	848	29	386	674	325	210	166	1	19	31	13	3	5	7200

B PERCENTAGE FREQUENCIES OF WIND DIRECTION AND SPEED:

DIRECTION	0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	47 OVER	TOTAL	AV. SPEED
N	.1	1.0	1.9	1.6	.5	.1				5.1	11.5
NNE	.1	.8	1.7	1.6	.3		+			4.5	11.6
NE	.2	.9	1.4	.9	.2	+				3.6	10.5
ENE	.1	1.0	1.6	.7	.1					3.4	9.8
E	.1	1.1	2.1	.9	+					4.2	9.8
ESE	.1	1.4	3.3	1.2	+					6.1	9.9
SE	.2	2.2	4.6	2.3	.3	+				9.5	10.3
SSE	.1	1.6	4.4	3.3	.7	.1				10.1	11.9
S	.1	2.0	5.5	4.2	.8	.1				12.6	11.7
SSW	.1	1.2	3.7	3.4	1.4	.2	+			9.9	13.2
SW	.1	1.0	2.5	2.0	.5	+	+			6.1	11.9
WSW	.1	1.0	1.7	1.4	.3	.1	+	+		4.7	12.0
W	.2	1.2	1.3	1.2	.3	+	+	+		4.1	11.1
WNW	.1	.9	1.6	1.5	.5	+				4.6	11.8
NW	.2	1.0	1.7	1.7	.8	.1				5.5	12.7
NNW	.1	.7	1.6	1.6	.7	.1				4.8	13.3
CALM	1.3									1.3	
TOTAL	3.0	19.0	40.3	29.3	7.4	.9	.1	+		100	11.4

C OCCURRENCES OF PRECIPITATION AMOUNTS:

FREQUENCY OF OCCURRENCE FOR EACH HOUR OF THE DAY

INTENSITIES	A.M. 1	2	3	4	5	6	7	8	9	10	11	NOON	P.M. 1	2	3	4	5	6	7	8	9	10	11	MID	NO. OF DAYS WITH
TRACE	18	16	18	19	26	22	31	13	18	17	22	16	22	19	17	22	19	17	17	14	18	18	17	17	45
.01 IN	6	4	8	6	6	7	6	6	4	4	4	2	1	6	3	1	6	4	2	4	4	2	3	1	14
.02 TO .09 IN	7	8	9	16	8	15	7	12	6	12	10	10	7	6	6	9	6	5	6	11	8	10	5	10	34
.10 TO .24 IN	7	3	1	1	3		3	1	7	5	3		2	2	3	2	3	3	5	4	2		4	4	23
.25 TO .49 IN	1	2	2	2				1	2		2	1				2	1	1	2				1		24
.50 TO .99 IN		2	1			1		1				1				2	1	1					1		10
1.00 TO 1.99 IN																	1	1						1	8
2.00 IN AND OVER																									3
TOTAL	39	35	39	44	43	45	47	34	37	38	41	30	32	33	29	38	37	32	32	33	32	30	31	33	161

D PERCENTAGE FREQUENCIES OF CEILING–VISIBILITY:

VISIBILITY (MILES)	CEILING (FEET) 0	100-200	300-400	500-900	1000-1900	2000-2900	3000-4900	5000-9500	OVER 9500	TOT
0 TO 1/8	+									+
3/16 TO 3/8	+	.1							+	.2
1/2 TO 3/4		.1	+	+					.1	.3
1 TO 2 1/2		.3	.7	.4	.1	+		+	.1	1.5
3 TO 6		+	.4	1.6	.9	.4	.3	.5	1.4	5.6
7 TO 15		+	.1	.8	2.8	2.8	5.3	8.5	72.0	92.4
20 TO 30										
35 OR MORE										
TOTAL	.1	.5	1.3	2.8	3.8	3.2	5.7	9.0	73.6	100

E PERCENTAGE FREQUENCIES OF SKY COVER, WIND, AND RELATIVE HUMIDITY:

HOUR OF DAY	CLOUDS SCALE 0-10: 0-3	4-7	8-10	WIND SPEED (M.P.H.): 0-3	4-12	13-24	25- & OVER	RELATIVE HUMIDITY (%): 0-29	30-49	50-69	70-79	80-89	90-100
00	54	15	31	3	69	26	2		1	23	31	23	22
01	52	10	38	4	70	24	1		1	20	28	24	28
02	51	13	37	4	73	21	1		1	16	24	27	31
03	45	14	41	4	73	23	+		+	11	25	31	33
04	35	18	47	3	72	24	+		+	9	20	35	36
05	31	17	52	3	72	25				7	20	36	37
06	29	14	56	6	67	27	+			10	22	39	29
07	31	12	57	7	51	42				21	33	26	20
08	30	16	55	4	52	44	+		4	36	27	18	15
09	29	18	53	2	49	47	1		10	46	23	11	10
10	28	16	56	2	43	54	1	+	20	48	13	11	8
11	27	20	53	3	41	54	2	+	28	46	11	7	7
12	25	26	49	1	46	51	2	1	37	41	12	3	6
13	29	22	49	2	44	52	2	3	39	39	10	4	6
14	28	26	47	2	43	52	3	5	41	36	10	3	5
15	28	23	48	1	45	52	2	6	43	34	8	5	4
16	32	24	44	2	43	52	2	6	42	33	8	4	7
17	36	22	41	1	50	49	+	6	40	35	9	4	7
18	42	20	38	2	56	41	1	5	35	36	12	6	6
19	46	14	39	2	70	28	+		26	40	17	10	8
20	47	16	38	4	72	24			13	45	19	14	9
21	46	17	37	3	74	22	+		9	41	21	17	12
22	52	15	33	4	74	22	+		6	35	23	20	15
23	55	12	32	3	74	23	1		2	32	26	21	19
AVG	38	18	45	3	59	37	1	1	16	31	19	17	16

DES MOINES, IOWA
Municipal AP

JULY
7440 Obs.

A TEMPERATURE AND WIND SPEED–RELATIVE HUMIDITY OCCURRENCES:

WIND	0-4 MPH						5-14 MPH						15-24 MPH						25 MPH AND OVER						TOTAL OBS
REL HUMID / TEMP (°F)	UNDER 30	30-49%	50-69%	70-79%	80-89%	90-100%	UNDER 30	30-49%	50-69%	70-79%	80-89%	90-100%	UNDER 30	30-49%	50-69%	70-79%	80-89%	90-100%	UNDER 30	30-49%	50-69%	70-79%	80-89%	90-100%	
109/105								1																	1
104/100							1	14					4	13					1	1					34
99/ 95		3					4	68	2				4	52	2										135
94/ 90	1	5	5				5	139	68				3	58	48					1	2				335
89/ 85	1	18	24	1			11	217	317	25	1		5	70	110	10				1	3				814
84/ 80	1	27	36	11			6	205	414	163	32		1	50	99	76	8			5	4	1	1		1140
79/ 75		18	46	39	28	3	2	120	391	287	237	58		35	62	54	39	3		8	4	2		1	1437
74/ 70		7	33	34	41	55		48	297	253	351	292		13	59	20	52	41			1	2		1	1600
69/ 65			17	25	57	82		7	132	181	279	342			14	14	27	36						4	1217
64/ 60			7	10	27	46			31	96	158	145			8	11	13	7				1			560
59/ 55				7	14	9				22	45	32			1	10	3	3							146
54/ 50					1	2					11	3					3	1							21
TOTAL	3	78	168	127	168	197	29	819	1552	1027	1114	872	17	291	403	195	145	91	1	16	14	6	1	6	7440

B PERCENTAGE FREQUENCIES OF WIND DIRECTION AND SPEED:

DIRECTION	0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	47 & OVER	TOTAL	AV SPEED
	HOURLY OBSERVATIONS OF WIND SPEED (IN MILES PER HOUR)										
N	.2	1.0	2.4	1.7	.3	+				5.7	11.1
NNE	.2	1.1	1.9	1.2	.3	+	+			4.6	10.7
NE	.2	1.4	2.6	.9	.1					5.2	9.5
ENE	.2	1.4	2.2	.7	.1					4.4	9.1
E	.2	1.3	1.9	.4	+					3.8	8.3
ESE	.2	1.6	2.3	.8	+	+				4.9	8.8
SE	.3	2.4	4.4	1.3	+					8.4	9.1
SSE	.1	2.7	5.1	2.0	.1	.1				10.1	9.8
S	.2	2.9	6.7	3.5	.3	.1				13.6	10.5
SSW	.1	1.2	3.7	3.4	.6	+				9.1	12.0
SW	.2	1.5	2.7	1.7	.7					6.9	11.2
WSW	.1	1.3	1.6	1.0	.1	+	+			4.2	10.1
W	.3	1.0	1.4	.7	.1					3.5	9.2
WNW	.2	1.2	1.9	1.0	.1	+	.1		+	4.5	10.3
NW	.2	1.4	1.7	1.1	.3	.1	+	+		4.9	11.3
NNW	.1	.6	1.8	1.4	.2	+				4.2	11.4
CALM	1.9									1.9	
TOTAL	5.1	23.9	44.4	22.7	3.4	.4	.1	+	+	100	10.1

C OCCURRENCES OF PRECIPITATION AMOUNTS:

INTENSITIES	AM 1	2	3	4	5	6	7	8	9	10	11	NOON	PM 1	2	3	4	5	6	7	8	9	10	11	MID	NO. OF DAYS WITH
TRACE	11	15	12	12	17	10	16	14	9	11	8	18	16	20	16	19	17	18	17	13	12	7	11	13	51
.01 IN	2	1	2	2	2	5	6	3	3	2	4	2	1	2		4	2	4			4	4	2	1	5
.02 TO .09 IN	4	7	9	7	10	8	10	8	9	6	4	1	4	2	3	3	6	4	5	5	5	4	4	5	23
.10 TO .24 IN	4	3		4	4	4	1	5	1	2	2	3			2			2		3	3	4	4	3	16
.25 TO .49 IN		1	1	2	2		1		2	2	1				2			2				1		1	19
.50 TO .99 IN		1	1							1						1			1		1	1	2		10
1.00 TO 1.99 IN			1	1						1									1						7
2.00 IN AND OVER																									3
TOTAL	21	28	26	23	35	28	34	30	24	25	19	24	21	24	23	27	25	30	24	21	25	21	23	23	13-

D PERCENTAGE FREQUENCIES OF CEILING–VISIBILITY:

VISIBILITY (MILES)	CEILING (FEET) 0	100-200	300-400	500-900	1000-1900	2000-2900	3000-4900	5000-9500	OVER 9500	TOT
0 TO 1/8	+	+	+							.1
3/16 TO 3/8	+	+	+						+	.1
1/2 TO 3/4		.1	+	+	+					.2
1 TO 2 1/2		.1	.3	.3	.1	+	+	+	.1	.7
3 TO 6			.2	.8	.6	.3	.6	.5	3.0	6.3
7 TO 15			.1	.6	2.5	2.3	3.9	6.[illegible]	76.4	92.4
20 TO 30										
35 OR MORE										
TOTAL	.1	.3	.7	1.7	3.1	2.6	4.6	7.4	79.5	100

E PERCENTAGE FREQUENCIES OF SKY COVER, WIND, AND RELATIVE HUMIDITY:

HOUR OF DAY	CLOUDS (SCALE 0-10) 0-3	4-7	8-10	WIND SPEED (M.P.H.) 0-3	4-12	13-24	25 & OVER	RELATIVE HUMIDITY (%) 0-29	30-49	50-69	70-79	80-89	90-100
00	59	15	27	8	75	17				21	25	35	19
01	57	13	29	6	77	16			1	11	23	39	26
02	56	14	29	5	75	15	+		1	10	21	35	34
03	56	15	30	5	78	16	1		1	8	16	34	41
04	47	18	35	8	76	15	+			6	16	35	44
05	42	16	42	10	73	16				5	13	34	48
06	39	13	46	10	73	17				5	17	37	40
07	41	14	45	5	71	24	+			12	34	31	23
08	38	17	45	5	66	25	1		2	32	29	26	12
09	38	14	46	5	60	35	1		5	46	25	15	7
10	38	19	43	4	61	35	1		15	53	17	8	7
11	35	21	44	3	56	38	1	+	28	48	12	7	5
12	29	27	43	3	53	43	1	1	38	41	11	6	3
13	30	26	43	1	56	43	1	2	44	37	10	3	3
14	29	31	39	3	51	45	2	3	47	37	7	3	3
15	33	31	36	4	52	43	1	4	48	35	8	3	3
16	36	25	39	2	53	45	1	4	47	35	6	5	2
17	41	25	35	2	61	36	1	2	44	36	9	5	4
18	47	19	34	2	72	25	+	+	38	42	9	7	4
19	52	16	31	5	77	17	1		21	47	19	8	4
20	55	16	29	6	80	14			8	49	22	15	6
21	57	16	27	5	81	14			2	45	25	20	8
22	61	14	25	5	77	15	1		+	33	30	23	14
23	61	17	23	7	77	15	+			25	32	26	16
AVG	45	19	36	5	68	26	1	1	16	30	18	19	16

A TEMPERATURE AND WIND SPEED—RELATIVE HUMIDITY OCCURRENCES:

Wind / Rel. Humid. / Temp °F	0-4 MPH Under 30	0-4 MPH 30-49	0-4 MPH 50-69	0-4 MPH 70-79	0-4 MPH 80-89	0-4 MPH 90-100	5-14 MPH Under 30	5-14 MPH 30-49	5-14 MPH 50-69	5-14 MPH 70-79	5-14 MPH 80-89	5-14 MPH 90-100	15-24 MPH Under 30	15-24 MPH 30-49	15-24 MPH 50-69	15-24 MPH 70-79	15-24 MPH 80-89	15-24 MPH 90-100	25 MPH and over Under 30	25 MPH and over 30-49	25 MPH and over 50-69	25 MPH and over 70-79	25 MPH and over 80-89	25 MPH and over 90-100	Total Obs.
99/ 95	2	1					11	33	8				15	11	4										85
94/ 90	3	10	5				20	97	94				12	59	30				1						331
89/ 85	1	11	23	3	2		7	136	244	24			1	55	74	3				5					589
84/ 80		10	46	22	10	2	6	164	305	185	51	3	2	45	95	34	3			1		1	1		986
79/ 75		18	45	25	28	7		127	345	297	271	86		33	68	47	24	5			2	2			1430
74/ 70			35	41	50	67	2	31	334	225	296	365	2	13	68	31	41	33		2	1	1	1		1639
69/ 65		1	15	27	45	125		20	131	187	249	426		4	28	19	32	32						3	1344
64/ 60			7	9	36	48		4	55	123	201	194			18	2	13	11							721
59/ 55				4	17	44			3	32	68	55			3	6	1	8							241
54/ 50					8	7				2	21	25				3	1	1							68
49/ 45						2					1	3													6
TOTAL	6	51	176	131	196	302	46	612	1519	1075	1158	1157	32	220	388	145	115	90	1	8	3	4	2	3	7440

B PERCENTAGE FREQUENCIES OF WIND DIRECTION AND SPEED:

Hourly observations of wind speed (in miles per hour)

Direction	0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	47 & over	Total	Avg. speed
N	.2	1.1	1.8	1.4	.2					4.6	10.5
NNE	.1	1.0	1.9	1.2	.2					4.4	10.7
NE	.3	1.4	1.7	1.1	+	+				4.5	9.6
ENE	.2	1.6	1.5	.5						3.9	8.4
E	.2	1.9	2.1	.6	.1					4.9	8.5
ESE	.2	2.5	2.9	.8	+					6.3	8.6
SE	.3	3.1	5.7	1.6	.1					10.8	9.1
SSE	.2	3.1	5.7	1.6	.1	+				10.7	9.3
S	.2	2.9	7.5	3.2	.4					14.2	10.4
SSW	.1	1.4	3.5	3.0	.3					8.3	11.3
SW	.2	1.5	2.3	1.6	.4	+				5.9	10.8
WSW	.1	1.0	1.6	.6	.2	+				3.5	9.8
W	.2	1.3	1.2	.5	.1	+				3.3	8.9
WNW	.2	1.1	1.3	.9	.2	.1				3.7	10.5
NW	.3	1.1	1.5	1.0	.3	+				4.3	10.5
NNW	.1	.6	1.5	1.0	.2	+				3.5	11.3
CALM	3.2									3.2	
TOTAL	6.4	26.4	43.8	20.3	2.7	.3				100	9.6

C OCCURRENCES OF PRECIPITATION AMOUNTS:

Frequency of occurrence for each hour of the day

Intensities	A.M. 1	2	3	4	5	6	7	8	9	10	11	Noon	P.M. 1	2	3	4	5	6	7	8	9	10	11	Mid	No. of days with
TRACE	11	17	22	21	12	26	19	20	26	18	13	17	23	23	14	15	12	17	13	9	7	11	12	16	46
.01 IN	5	11	7	5	12	7	13	3	4	3	5	5	4	4		6	2	1	2	2	5	2	3	4	5
.02 TO .09 IN	9	8	7	4	11	11	7	11	10	10	8	7	6	1	8	4	10	5	3	6	6	4	5	8	29
.10 TO .24 IN	7	2	2	3	2	3	5	4	3	3	3	1			1		1	3	7	4	5	2	4	3	19
.25 TO .49 IN	2	2	1	1	1			4	1					2		1		1	1	2				4	18
.50 TO .99 IN	1	1	1		1										1	1		1	1	1	1	1	1	1	16
1.00 TO 1.99 IN	1																				1	1			10
2.00 IN AND OVER																									2
TOTAL	36	41	40	34	39	47	44	42	44	34	29	30	33	30	24	27	25	28	27	24	25	21	25	36	145

D PERCENTAGE FREQUENCIES OF CEILING—VISIBILITY:

Visibility (miles)	Ceiling (feet) 0	100-200	300-400	500-900	1000-1900	2000-2900	3000-4900	5000-9500	Over 9500	Tot
0 TO 1/8	.1	+							+	.1
3/16 TO 3/8		+							+	.1
1/2 TO 3/4		+	+				+		.1	.2
1 TO 2 1/2		.1	.5	.3	.1	.1	.1	+	.2	1.4
3 TO 6		+	.3	.8	.6	.4	.5	.8	3.4	6.9
7 TO 15		+	.1	.9	1.7	1.6	3.8	6.8	76.3	91.3
20 TO 30										
35 OR MORE										
TOTAL	.1	.2	.9	2.0	2.4	2.1	4.5	7.7	80.1	100

E PERCENTAGE FREQUENCIES OF SKY COVER, WIND, AND RELATIVE HUMIDITY:

Hour of day	Clouds (scale 0-10) 0-3	4-7	8-10	Wind speed (m.p.h.) 0-3	4-12	13-24	25 & over	Relative humidity (%) 0-29	30-49	50-69	70-79	80-89	90-100
00	58	13	29	6	81	12	+		1	16	23	30	30
01	56	13	31	7	82	11			1	12	19	30	33
02	55	10	35	8	80	12			+	10	15	33	42
03	54	9	36	8	81	11			+	8	14	32	45
04	52	12	36	10	76	14			+	7	13	28	51
05	43	15	41	12	77	11			+	5	11	28	55
06	42	14	44	10	80	10			+	6	10	31	53
07	42	14	44	10	69	20			+	11	18	37	34
08	38	15	47	8	66	26	+		1	21	26	30	21
09	38	15	46	7	64	29			6	31	33	18	12
10	38	18	45	5	56	38			13	43	25	12	7
11	38	18	44	6	54	39	1	+	20	50	16	3	5
12	37	19	44	4	53	42	1	1	25	48	16	5	5
13	34	25	42	3	54	43	+	3	30	47	12	5	2
14	34	25	41	4	51	45	1	4	35	44	11	5	2
15	32	28	40	3	57	40	1	6	36	40	10	5	3
16	36	27	37	4	55	41	+	6	34	42	10	5	3
17	43	21	36	3	66	30	+	5	31	42	12	7	3
18	48	19	33	4	77	19	+	2	25	45	15	9	5
19	50	16	34	7	80	12	+		13	43	22	14	8
20	54	17	29	8	78	13	1		7	32	31	16	14
21	60	12	28	5	84	11			5	25	28	24	18
22	64	10	26	5	82	12	+		2	23	28	28	20
23	61	14	25	5	82	13	+		1	19	20	35	24
AVG	46	17	37	6	70	23	+	1	12	28	18	20	21

DES MOINES, IOWA
Municipal AP

SEPTEMBER
7200 Obs.

A TEMPERATURE AND WIND SPEED—RELATIVE HUMIDITY OCCURRENCES:

WIND	0-4 M.P.H.						5-14 M.P.H.						15-24 M.P.H.						25 M.P.H. AND OVER						TOTAL OBS
REL. HUMID. / TEMP °F.	Under 30	30-49	50-69	70-79	80-89	90-100	Under 30	30-49	50-69	70-79	80-89	90-100	Under 30	30-49	50-69	70-79	80-89	90-100	Under 30	30-49	50-69	70-79	80-89	90-100	
99/ 95							1						7	6					7	1					22
94/ 90			1				8	34	6				20	44	1				1						115
89/ 85	1	1	3				18	52	37	1			16	51	27				10	4	6				227
84/ 80	11	7	2				36	93	74	20	3		25	56	45	3			3	5	3				386
79/ 75	7	10	7	6	3		40	144	143	57	21	3	33	109	50	22	12		1	2	7	2	1		680
74/ 70	3	28	16	3	4	8	28	143	184	125	100	28	12	107	64	21	30	14	1	1	1	1	1		923
69/ 65		17	27	8	9	23	15	161	209	134	160	168	10	75	61	26	21	30	1	2	3	1			1161
64/ 60		7	26	26	14	42	3	138	259	138	172	255	1	49	77	20	23	24		1	2	1			1278
59/ 55	1	5	18	19	37	38	3	50	234	167	169	179		15	42	28	30	33						1	1069
54/ 50		3	11	11	37	32		14	147	145	191	141	1	9	27	6	19	10		6	5				815
49/ 45			5	11	19	14		7	52	65	95	76			14	12	5	5		2	7				389
44/ 40				2	9	5		1	14	23	28	24			4	1					3				114
39/ 35						1			2	3	1	8													15
34/ 30										1	5														6
TOTAL	23	78	116	86	132	163	152	837	1361	879	945	882	125	521	412	139	140	116	24	24	37	5	2	1	7200

B PERCENTAGE FREQUENCIES OF WIND DIRECTION AND SPEED:

DIRECTION	HOURLY OBSERVATIONS OF WIND SPEED (IN MILES PER HOUR) 0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	47 & OVER	TOTAL	AV. SPEED
N	.1	.8	2.2	1.8	.3	+				5.2	11.6
NNE	.1	.8	1.8	1.2	.2					4.0	11.2
NE	.3	1.2	1.5	.8	.1					3.9	9.3
ENE	.1	1.0	1.5	.6						3.2	9.1
E	.1	1.0	1.7	.5	+					3.3	8.9
ESE	.1	1.8	2.8	.8	+					5.5	8.9
SE	.2	1.7	4.2	1.6	.1					7.8	10.0
SSE	.1	1.9	5.6	2.6	.2	+				10.5	10.5
S	.2	1.9	5.8	3.8	.8	.1				12.6	11.7
SSW	.1	1.0	3.5	2.6	1.1	.2				8.5	12.8
SW	.2	1.4	1.9	1.2	.4	.1	+			5.3	11.3
WSW	.2	1.4	1.7	1.1	.2	.1	+			4.7	10.5
W	.2	1.5	1.8	1.1	.3	+	+			5.0	10.2
WNW	.2	1.5	2.2	1.5	.7	.3	+			6.4	12.3
NW	.1	1.1	2.6	2.0	1.0	.2	+			7.0	12.6
NNW	.1	.6	2.0	1.8	.5	.1				5.2	12.8
CALM	2.0									2.0	
TOTAL	4.3	20.7	42.7	25.1	5.9	1.2	.1			100	10.8

C OCCURRENCES OF PRECIPITATION AMOUNTS:

FREQUENCY OF OCCURRENCE FOR EACH HOUR OF THE DAY

INTENSITIES	A.M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	NOON	P.M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	MID	NO. OF DAYS WITH
TRACE	11	10	15	15	9	9	16	22	16	19	12	11	18	14	13	16	10	15	8	7	8	12	10	14	37
.01 IN	3	7	6	7	5	5	6	2	2	1	5	4	3	6	2	1	3	2		3	2	1	3	4	8
.02 TO .09 IN	8	7	8	4	7	10	7	10	6	9	9	8	7	7	7	5	6	6	7	5	6	5	7	5	23
.10 TO .24 IN	8	7	4	5	3	3	4	1	3	1	2	1	2	3	1	1	1					1		4	17
.25 TO .49 IN			2							1	1	1				1			2				1		11
.50 TO .99 IN	1									1												1	1	1	13
1.00 TO 1.99 IN																									3
2.00 IN AND OVER																									
TOTAL	31	31	35	31	24	27	33	35	27	31	29	25	30	30	23	24	20	23	17	15	16	20	22	28	112

D PERCENTAGE FREQUENCIES OF CEILING-VISIBILITY:

VISIBILITY (MILES)	CEILING (FEET) 0	100-200	300-400	500-900	1000-1900	2000-2900	3000-4900	5000-9500	OVER 9500	TOT.
0 TO 1/8	.1	+		+		+			+	.2
3/16 TO 3/8		+					+		+	.1
1/2 TO 3/4		+	+	+				+	+	.1
1 TO 2 1/2		+	.3	.5	.1	+	+	.1	.1	1.2
3 TO 6		.1	.3	1.5	.8	.3	.5	.6	1.6	5.7
7 TO 15			.1	1.1	2.5	2.3	3.3	7.4	76.0	92.6
20 TO 30										
35 OR MORE										
TOTAL	.1	.1	.7	3.1	3.5	2.6	3.9	8.3	77.8	100

E PERCENTAGE FREQUENCIES OF SKY COVER, WIND, AND RELATIVE HUMIDITY:

HOUR OF DAY	CLOUDS SCALE 0-10: 0-3	4-7	8-10	WIND SPEED (M.P.H.): 0-3	4-12	13-24	25 & OVER	RELATIVE HUMIDITY (%): 0-29	30-49	50-69	70-79	80-89	90-100
00	64	7	29	6	73	21		+	7	23	24	26	20
01	62	10	27	4	73	13			6	21	22	27	25
02	63	8	30	5	76	18	1		5	20	16	30	28
03	62	7	31	6	72	22			4	19	15	31	31
04	63	10	26	7	71	22			3	16	16	32	32
05	57	13	30	7	73	20	+		2	14	16	31	37
06	51	12	37	7	71	22	+		2	12	18	27	41
07	51	10	40	6	70	23	1		3	16	22	32	27
08	49	10	41	4	60	34	2		7	28	27	22	16
09	50	9	41	6	48	44	2	1	13	43	16	15	11
10	50	12	38	3	47	47	3	3	23	43	13	8	9
11	49	12	39	5	44	48	3	6	37	36	8	6	8
12	48	12	39	2	43	51	4	9	42	30	6	5	7
13	46	17	37	2	45	49	4	14	44	25	5	6	5
14	47	14	39	1	44	51	4	17	44	22	6	6	5
15	47	15	38	2	44	50	4	17	45	20	3	5	5
16	48	15	37	3	46	49	2	15	45	21	6	5	5
17	47	15	38	2	60	38		11	43	27	8	6	5
18	52	12	36	6	71	23		6	34	38	7	10	5
19	51	19	30	3	78	19		3	24	39	15	9	9
20	57	14	29	5	76	19	+	2	18	37	22	11	11
21	64	12	24	4	76	20		2	14	31	28	14	12
22	63	12	25	4	78	17		+	12	30	25	19	15
23	65	9	26	4	76	19	1	+	8	30	17	23	19
AVG	54	12	34	4	63	31	1	5	22	27	15	17	16

DES MOINES, IOWA
Municipal AP

OCTOBER
7440 Obs.

A TEMPERATURE AND WIND SPEED–RELATIVE HUMIDITY OCCURRENCES:

WIND	0-4 M.P.H.						5-14 M.P.H.						15-24 M.P.H.						25 M.P.H. AND OVER						TOTAL OBS.
REL. HUMID. / TEMP °F	UNDER 30	30-49	50-69	70-79	80-89	90-100	UNDER 30	30-49	50-69	70-79	80-89	90-100	UNDER 30	30-49	50-69	70-79	80-89	90-100	UNDER 30	30-49	50-69	70-79	80-89	90-100	
94/ 90													6												6
89/ 85							2	4	1				6	1	4				7						25
84/ 80							17	27	12				7	24	5	1				9					102
79/ 75		2	6				24	51	26	10	2		13	45	13	6	9		1	2	5	1			216
74/ 70	1	6	9	2			30	84	68	24	24	8	26	81	30	7	9		1	2	3				415
69/ 65	3	11	11	9		1	24	149	114	53	43	33	40	95	35	12	7	4	1	5	5		1	1	657
64/ 60	6	13	13	7	12	10	24	170	169	64	73	102	31	71	53	17	11	8	7	5	1	1			868
59/ 55	1	17	20	3	4	30	14	215	221	108	55	196	13	88	44	24	15	19	1	8	6				1102
54/ 50		8	17	11	20	18	10	141	326	121	122	111	13	55	91	25	19	15	4	8	4	5		5	1149
49/ 45		8	21	13	16	14	2	81	270	122	153	102	9	48	84	37	48	44	1	4	11	10	3	8	1109
44/ 40			14	18	12	5	2	51	145	138	152	62		30	53	49	68	11		1	10	22	6	2	851
39/ 35		3	15	5	14	7		33	97	81	126	54		6	38	33	26	5		1	10	4	4	4	566
34/ 30			2	1	8	5		9	59	64	42	21			28	9	2	2			2	2		1	257
29/ 25			4	2		1			27	27	23	1			8		1								94
24/ 20					3				5		13	2													23
TOTAL	11	68	132	71	89	91	149	1015	1540	812	828	692	164	544	486	220	215	108	23	45	57	45	14	21	7440

B PERCENTAGE FREQUENCIES OF WIND DIRECTION AND SPEED:

DIRECTION	0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	47 OVER	TOTAL	AV SPEED
	HOURLY OBSERVATIONS OF WIND SPEED (IN MILES PER HOUR)										
N	.2	.9	3.0	2.8	.8	.1	+			7.7	12.4
NNE	.1	.8	2.0	2.2	.4	+				5.5	12.1
NE	.2	1.0	1.2	.5	.1					2.9	9.2
ENE	+	.8	.9	.2						1.8	8.2
E	.1	1.0	1.1	.2						2.4	7.9
ESE	.1	1.5	3.2	.4						5.2	8.9
SE	.1	2.1	4.5	1.8	.2					8.7	9.9
SSE	.1	1.5	4.3	2.3	.4	+				8.6	11.0
S	.1	1.7	5.6	3.1	.6	.1				11.2	11.3
SSW	.1	.8	3.5	3.1	.8	.2				8.5	12.9
SW	.1	.9	1.8	1.4	.5	.1				4.7	12.1
WSW	.2	.9	1.5	1.1	.2	+				3.9	10.9
W	.1	1.2	1.8	.7	.4	.2				4.4	11.2
WNW	.1	1.1	2.2	1.8	.9	.5	.1			6.7	13.7
NW	.1	1.1	2.9	2.5	1.5	.7	.1			8.9	14.5
NNW	.1	.9	2.0	2.4	1.3	.5	+			7.2	14.7
CALM	1.5									1.5	
TOTAL	3.3	18.0	41.4	26.5	8.0	2.5	.3			100	11.6

C-10

C OCCURRENCES OF PRECIPITATION AMOUNTS:

INTENSITIES	A.M. 1	2	3	4	5	6	7	8	9	10	11	NOON	P.M. 1	2	3	4	5	6	7	8	9	10	11	MID	NO. OF DAYS WITH
	FREQUENCY OF OCCURRENCE FOR EACH HOUR OF THE DAY (A.M. HOUR ENDING AT / P.M. HOUR ENDING AT)																								
TRACE	15	15	22	13	17	16	20	18	18	16	15	17	15	15	16	20	14	13	23	20	11	15	16	15	36
.01 IN	7	3	4	5	3	6	7	4	6	4	5	4	5	2	7	3	4	4	1	3	4	4	7	7	8
.02 TO .09 IN	3	6	5	8	8	7	4	8	6	7	8	8	7	8	5	7	5	5	5	7	11	7	7	5	31
.10 TO .24 IN	2	2	3	3	2	2	1	2	2	2	2	1	2	3	1	1	1	1	2	1	2	4	2	4	9
.25 TO .49 IN							1			1	1										1	1			15
.50 TO .99 IN																				1					8
1.00 TO 1.99 IN																									3
2.00 IN AND OVER																									
TOTAL	27	31	34	29	30	31	33	32	32	30	31	30	29	28	29	31	24	23	31	32	29	31	32	31	110

D PERCENTAGE FREQUENCIES OF CEILING–VISIBILITY:

VISIBILITY (MILES)	CEILING (FEET) 0	100-200	300-400	500-900	1000-1900	2000-2900	3000-4900	5000-9500	OVER 9500	TOT
0 TO 1/8	.1	.1							+	.2
3/16 TO 3/8	.1	.1							+	.2
1/2 TO 3/4	.1	.1	.1		+			+	+	.4
1 TO 2 1/2		.2	.6	.5	.2	.1	+	.1	.2	1.7
3 TO 6			.6	1.7	.8	.5	.4	.7	2.1	6.7
7 TO 15			+	.8	3.4	3.6	5.8	6.3	71.0	90.8
20 TO 30										
35 OR MORE										
TOTAL	.3	.4	1.3	2.9	4.4	4.2	6.3	7.0	73.3	100

E PERCENTAGE FREQUENCIES OF SKY COVER, WIND, AND RELATIVE HUMIDITY:

HOUR OF DAY	CLOUDS SCALE 0-10: 0-3	4-7	8-10	WIND SPEED (M.P.H.): 0-3	4-12	13-24	25-& OVER	RELATIVE HUMIDITY (%): 0-29	30-49	50-69	70-79	80-89	90-100
00	59	9	32	5	71	22	2		11	36	22	17	14
01	61	9	31	4	69	27	1		8	32	23	23	14
02	60	9	31	4	71	24	1	+	6	27	25	26	16
03	60	9	31	5	71	23	2	1	5	24	26	26	19
04	62	7	31	4	72	23	1	+	5	19	25	29	20
05	59	7	33	4	71	24	1		4	18	24	31	23
06	48	13	39	2	73	24	1	+	4	17	20	35	25
07	47	10	43	2	69	27	2		4	21	18	34	23
08	45	13	42	4	59	35	3		8	28	25	24	15
09	45	12	43	3	52	41	4	+	15	40	21	15	9
10	46	11	43	5	43	47	5	2	26	43	13	7	9
11	44	12	45	3	39	54	5	5	35	37	8	7	8
12	43	12	46	3	38	53	6	10	41	30	7	6	6
13	44	10	46	3	35	56	6	15	44	23	6	5	6
14	42	15	43	3	35	55	7	20	43	22	6	4	5
15	43	14	43	2	40	53	5	21	42	21	6	3	6
16	44	13	44	2	44	50	4	20	44	21	5	4	6
17	44	14	43	5	59	33	3	9	47	25	8	4	7
18	48	12	40	5	71	21	3	4	42	32	8	6	8
19	53	11	36	3	72	24	2	2	33	37	12	8	9
20	55	10	35	2	70	27	1	1	27	41	10	11	10
21	56	9	35	5	68	27	1	1	21	40	15	12	11
22	58	9	33	2	67	31	1	+	16	41	17	15	11
23	59	10	32	3	67	29	1		10	42	18	17	12
AVG	51	11	38	3	59	35	3	5	22	30	15	15	12

A TEMPERATURE AND WIND SPEED–RELATIVE HUMIDITY OCCURRENCES:

WIND	0-4 MPH						5-14 MPH						15-24 MPH						25 MPH AND OVER						TOTAL OBS.
REL. HUMID / TEMP °F	UNDER 30	30-49%	50-69%	70-79%	80-89%	90-100%	UNDER 30	30-49%	50-69%	70-79%	80-89%	90-100%	UNDER 30	30-49%	50-69%	70-79%	80-89%	90-100%	UNDER 30	30-49%	50-69%	70-79%	80-89%	90-100%	
79/ 75																				1					1
74/ 70								9	3					9	6					4	1				32
69/ 65		3		1			16	16	5	6	2		1	30	9	11	5	1		3	1				110
64/ 60	1	5	3	2	2		13	36	25	5	24	14	4	38	36	9	12	8	1	1	1				240
59/ 55	1	6	1		1	6	12	65	47	8	34	78	16	51	36	3	6	17	2	9	3				402
54/ 50		8	6	1	1	10	9	81	114	28	21	83	3	62	51	12	9	29	8	9	8				553
49/ 45		4	11	8	1	7	5	97	196	81	38	50	5	78	90	31	14	24		11	6				757
44/ 40		4	8	4	6	16	6	61	229	106	66	86	1	59	112	77	20	26		3	27	3	1	1	922
39/ 35			10	13	6	14	1	57	221	159	120	72	1	22	133	100	70	37	1	10	26	10	4	1	1088
34/ 30		3	12	5	14	3		21	200	146	183	87	1	17	129	83	55	53		5	39	32	8	8	1104
29/ 25			5	4	9	12		12	107	131	115	72		4	63	86	41	30		1	30	14	5	8	749
24/ 20		3	7	11	10	7		14	80	101	95	32		6	66	60	26	16			19	22	18	4	597
19/ 15		1	4	4	1	3		5	52	78	50	6		4	35	41	17	1			6	13	1	1	323
14/ 10		1	3	5	4	1		4	30	26	23	1		3	13	26	13			1	15	9	7	1	186
09/ 05			2		3			7	9	15	20			2	5	2	6				17	6	2		96
04/ 00				1					4	10	8			2	7					1	2	2			37
-01/-05									3																3
TOTAL	2	38	72	59	58	79	62	485	1325	900	799	581	32	387	791	541	294	242	12	59	201	111	46	24	7200

B PERCENTAGE FREQUENCIES OF WIND DIRECTION AND SPEED:

DIRECTION	HOURLY OBSERVATIONS OF WIND SPEED (IN MILES PER HOUR) 0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	47 & OVER	TOTAL	AV. SPEED
N	.2	.5	1.4	2.1	1.1	.2				5.4	14.5
NNE	+	.3	.7	.8	.3	+				2.2	13.0
NE	.1	.4	1.0	1.2	.2					3.0	11.9
ENE	.1	.4	1.1	.5	+					2.1	9.9
E	.1	.4	1.4	.3	+					2.2	9.7
ESE	.1	.7	1.6	.6	+	+				3.0	9.6
SE	.1	.9	2.9	1.3	.2					5.4	10.7
SSE	.1	.7	2.7	2.1	.2					5.7	11.5
S	.1	1.2	4.5	3.9	.7	+				10.5	12.1
SSW	.1	.8	3.3	3.0	.8	.1	+	+		8.2	12.9
SW	.1	1.0	2.6	2.0	.6	.1	.1	+		6.6	12.5
WSW	+	1.2	2.6	1.9	.7	.2	.1			6.7	12.6
W	.2	1.2	2.9	1.8	.4	.3	.1	+		6.9	12.4
WNW	+	.8	2.5	3.2	2.2	1.3	.5	.1	+	10.6	17.1
NW	.1	.8	2.8	4.3	2.9	1.7	.4	.1		13.1	17.4
NNW	.1	.4	1.6	2.7	1.9	.6	.2	+		7.6	16.8
CALM	.8									.8	
TOTAL	2.3	11.9	35.5	31.8	12.2	4.6	1.4	.3	+	100	13.6

C OCCURRENCES OF PRECIPITATION AMOUNTS:

INTENSITIES	FREQUENCY OF OCCURRENCE FOR EACH HOUR OF THE DAY — A.M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	NOON	P.M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	MID	NO. OF DAYS WITH
TRACE	27	23	27	20	28	28	32	28	29	23	26	31	25	29	28	26	19	16	25	26	19	23	20	22	62
.01 IN	9	3	3	8	2	5	3	8	5	3	2	5	5	3	3	5	4	5	4	3	4	3	6	5	15
.02 TO .09 IN	2	5	6	3	4	4	5	5	4	9	10	5	4	7	8	3	6	7	6	10	9	9	7	7	20
.10 TO .24 IN	3	3		2	2	2	2	1	1							1	1		3	1	3		1	2	7
.25 TO .49 IN			1		2	1					1	1					1			1	1	2		1	8
.50 TO .99 IN			1										1						1						6
1.00 TO 1.99 IN																									5
2.00 IN AND OVER																									
TOTAL	41	34	38	33	38	40	42	43	39	35	39	42	35	39	39	35	31	29	39	41	36	37	34	37	123

D PERCENTAGE FREQUENCIES OF CEILING–VISIBILITY:

VISIBILITY MILES	CEILING (FEET) 0	100-200	300-400	500-900	1000-1900	2000-2900	3000-4900	5000-9500	OVER 9500	TOTAL
0 TO 1/8	.4	.1	+						.1	.7
3/16 TO 3/8	.1	.1	+	+					+	.3
1/2 TO 3/4		.2	.2	.3	+	+	+		+	.9
1 TO 2 1/2		.5	.6	1.1	.4	.1	.2		.2	3.3
3 TO 6		+	.3	1.8	1.1	.6	.3	.5	1.6	6.0
7 TO 15			.1	1.3	4.8	4.6	6.0	6.8	65.6	88.8
20 TO 30										
35 OR MORE										
TOTAL	.5	.8	1.5	4.5	6.2	5.3	6.5	7.3	67.5	100

E PERCENTAGE FREQUENCIES OF SKY COVER, WIND, AND RELATIVE HUMIDITY:

HOUR OF DAY	CLOUDS SCALE 0-10: 0-3	4-7	8-10	WIND SPEED (M.P.H.): 0-3	4-12	13-24	25-& OVER	RELATIVE HUMIDITY (%): 0-29	30-49	50-69	70-79	80-89	90-100
00	51	9	40	3	54	38	5	+	6	32	26	21	15
01	48	13	40	4	52	39	5	+	4	27	31	20	17
02	53	9	38	1	56	39	4		3	26	30	24	16
03	52	9	38	2	56	38	5		3	24	30	24	19
04	54	8	38	2	57	38	4		3	24	26	28	19
05	52	11	37	1	55	40	4		2	23	27	28	20
06	47	10	43	3	52	41	4		3	23	24	30	21
07	36	16	48	2	53	41	4		3	18	29	29	22
08	34	12	53	2	48	44	6		3	25	28	26	18
09	35	14	51	2	40	52	7		5	34	26	19	16
10	36	10	54	3	35	54	9		12	42	23	11	12
11	35	11	54	4	31	54	11	+	23	41	16	9	10
12	34	14	52	2	30	57	11	1	30	40	12	8	8
13	34	13	53	2	29	57	12	5	33	35	15	5	8
14	34	11	55	3	26	61	10	6	31	37	13	7	6
15	33	14	53	3	31	55	11	8	31	37	10	7	6
16	31	17	52	2	41	50	8	6	31	37	13	7	6
17	35	14	50	2	55	37	6	3	25	41	15	10	6
18	39	13	48	3	57	35	5	3	21	42	17	10	8
19	42	14	44	3	56	36	5	1	15	41	22	12	9
20	47	10	44	2	58	36	4	1	11	40	27	11	11
21	49	11	40	2	59	35	5	+	10	40	25	13	11
22	44	11	40	3	56	38	3	+	7	38	24	16	12
23	50	8	42	3	51	41	5		7	31	28	21	13
AVG	42	12	46	2	47	44	6	2	13	33	22	17	13

DES MOINES, IOWA
Municipal AP

DECEMBER
7440 Obs.

A TEMPERATURE AND WIND SPEED–RELATIVE HUMIDITY OCCURRENCES:

WIND	0-4 M.P.H						5-14 M.P.H						15-24 M.P.H						25 M.P.H AND OVER						TOTAL OBS
REL. HUMIDITY / TEMP °F	UNDER 30	30-49	50-69	70-79	80-89	90-100	UNDER 30	30-49	50-69	70-79	80-89	90-100	UNDER 30	30-49	50-69	70-79	80-89	90-100	UNDER 30	30-49	50-69	70-79	80-89	90-100	
64/ 60															1	1	4			1	1				8
59/ 55		2						5	3	3	7		1	4	8	3	13	4		3					56
54/ 50		5						20	25	12	8	19	5	26	17	12	15	6		1	4	2			177
49/ 45		1	3	1				32	69	18	5	23		38	38	8	10	9	1	3	7	1			267
44/ 40		1	8	1	2	1		30	130	54	31	63		26	90	20	3	18		3	20	3	1	1	506
39/ 35		1	6	2	3	8		12	187	149	102	140		21	136	110	45	48		1	19	12	3	2	1007
34/ 30			3	14	12	36		9	186	199	215	346		8	112	112	109	87			12	8	10	11	1489
29/ 25			3	10	14	45		6	121	171	222	242		6	89	116	118	80		3	13	19	25	1	1304
24/ 20		3	17	8	7	10		6	110	139	208	77		3	62	70	60	15		3	3	9	11		821
19/ 15		3	7	7	9	12		18	50	116	135	80		4	48	50	62	6		3	1	13	3		627
14/ 10		2	6	4	8	7		13	62	72	122	24		2	35	50	41	9		2	9	7			475
09/ 05			4		6	2			52	38	89	2		3	34	33	19			1	6	7			296
04/ 00			3	2	5				29	54	48			4	43	23	2			1	4	4			222
-01/-05			6	4	8			1	29	31	18		1	2	17	2					4				123
-06/-10			7	1				3	29	3				3	8										54
-11/-15								3	2					1	2										8
TOTAL		18	73	54	74	121		158	1084	1059	1210	1016	7	151	740	610	501	282	1	25	103	85	53	15	7440

B PERCENTAGE FREQUENCIES OF WIND DIRECTION AND SPEED:

DIRECTION	HOURLY OBSERVATIONS OF WIND SPEED (IN MILES PER HOUR) 1-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	47 & OVER	TOTAL	AV. SPEED
N	.1	.7	1.6	2.9	1.0	.2	.1			6.7	14.7
NNE	+	.5	1.2	1.6	.6	+				4.1	13.4
NE	.1	.6	1.7	.8	.4					3.5	11.4
ENE	.1	.8	1.8	.6	.1					3.4	9.6
E	+	.7	1.3	.4	.1					2.4	9.8
ESE	.1	1.1	2.0	.8	.1	+				4.0	9.9
SE	.1	1.5	2.7	1.5	.1					5.9	10.1
SSE	+	.9	2.4	2.3	.3	+				6.0	11.9
S	.1	1.3	3.7	2.6	.6	+				8.4	11.6
SSW	.1	.8	2.9	2.1	.5	.1	.1			6.6	12.3
SW	.1	.8	3.1	2.0	.6	.1	.1	+		6.6	12.5
WSW	.1	1.0	2.2	1.5	.6	.2	.2			5.8	12.8
W	.1	.9	2.4	1.5	.3	.1	.1			5.5	12.0
WNW	.1	.9	2.5	3.2	1.6	.8	.1			9.2	15.0
NW	.1	.9	2.8	4.9	2.7	.8	.1	+		12.4	15.7
NNW	.1	.7	2.0	3.4	1.7	.6	.1			8.6	15.5
CALM	.9									.9	
TOTAL	2.2	14.3	36.5	32.0	11.3	2.9	.8	+		100	12.9

C OCCURRENCES OF PRECIPITATION AMOUNTS:

INTENSITIES	FREQUENCY OF OCCURRENCE FOR EACH HOUR OF THE DAY — A.M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	NOON	P.M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	MID.	NO. OF DAYS WITH
TRACE	34	41	40	40	39	41	43	43	45	43	43	35	37	35	33	38	35	27	38	39	40	36	32	38	81
.01 IN	5	5	7	9	7	10	5	4	8	11	6	6	7	1	4	3	9	5	6	7	7	4	13	6	8
.02 TO .09 IN	6	3	6	6	9	7	11	13	12	11	8	10	7	12	10	7	3	7	5	7	4	7	4	5	31
.10 TO .24 IN					1	1		1					1			1	1				1				15
.25 TO .49 IN																									11
.50 TO .99 IN																									2
1.00 TO 1.99 IN																									
2.00 IN AND OVER																									
TOTAL	45	49	53	55	56	59	59	61	65	65	57	51	52	48	47	49	48	39	49	53	52	47	49	49	148

D PERCENTAGE FREQUENCIES OF CEILING–VISIBILITY:

VISIBILITY (MILES)	CEILING (FEET) 0	100-200	300-400	500-900	1000-1900	2000-2900	3000-4900	5000-9500	OVER 9500	TOT.
0 TO 1/8	.6	.4		+						1.0
3/16 TO 3/8	.4	.5	+	+	+	+			+	1.0
1/2 TO 3/4	+	.9	.2	.3	.2				+	1.7
1 TO 2 1/2		1.3	1.9	1.4	1.3	.2	+	.1	.4	6.5
3 TO 6		+	1.2	2.5	1.7	.8	.4	.6	2.4	9.6
7 TO 15			.1	2.1	7.8	5.3	3.3	5.6	55.9	80.2
20 TO 30										
35 OR MORE										
TOTAL	1.0	3.1	3.4	6.3	11.0	6.3	3.8	6.3	58.8	100

E PERCENTAGE FREQUENCIES OF SKY COVER, WIND, AND RELATIVE HUMIDITY:

HOUR OF DAY	CLOUDS SCALE 0-10: 0-3	4-7	8-10	WIND SPEED (M.P.H.): 0-3	4-12	13-24	25-& OVER	RELATIVE HUMIDITY (%): 0-29	30-49	50-69	70-79	80-89	90-100
00	43	10	47	2	56	40	3		2	18	29	31	20
01	42	7	51	2	57	38	3		1	18	26	33	22
02	42	10	48	2	57	37	3		+	19	26	31	23
03	42	8	50	3	56	39	2		+	18	24	34	23
04	41	7	52	2	55	41	2		1	16	20	39	24
05	40	6	53	3	55	38	5		+	15	24	36	25
06	40	6	54	3	50	43	4		1	13	27	34	26
07	32	10	58	3	52	41	4		+	13	24	36	27
08	28	9	63	3	52	43	2		+	14	26	33	27
09	26	9	65	3	44	49	4		2	17	33	28	21
10	27	11	62	3	44	48	5		2	28	32	19	19
11	27	10	63	2	41	53	4		4	36	29	14	17
12	28	9	63	1	39	54	7	+	8	41	22	15	14
13	28	10	62	2	37	54	6	+	14	43	19	12	13
14	27	11	62	2	41	51	6	1	16	45	15	12	11
15	27	10	63	1	40	54	5	1	18	41	19	9	12
16	27	7	65	1	52	43	5	+	15	37	22	14	12
17	28	13	59	2	58	38	3	+	9	39	21	17	13
18	33	12	56	2	58	36	4		6	37	21	20	15
19	35	11	54	2	54	41	3		4	31	26	22	17
20	39	9	53	2	55	41	3		2	30	24	24	19
21	39	8	53	3	53	40	5		3	27	26	25	20
22	40	12	49	3	57	37	4		2	25	24	29	20
23	42	8	50	3	56	39	2		3	22	25	30	21
AVG	34	9	56	2	51	43	4	+	5	27	24	25	19

A TEMPERATURE AND WIND SPEED–RELATIVE HUMIDITY OCCURRENCES:

WIND	0-4 M.P.H.						5-14 M.P.H.						15-24 M.P.H.						25 M.P.H. AND OVER						TOTAL OBS
REL. HUMID / TEMP °F	UNDER 30	30-49%	50-69%	70-79%	80-89%	90-100%	UNDER 30	30-49%	50-69%	70-79%	80-89%	90-100%	UNDER 30	30-49%	50-69%	70-79%	80-89%	90-100%	UNDER 30	30-49%	50-69%	70-79%	80-89%	90-100%	
109/105								+																	+
104/100							+	2					+	1					+	+					4
99/ 95	+						2	11	2				3	9	1				1	+					28
94/ 90	1	2	1				5	32	20				6	21	14				+	+	+				102
89/ 85	+	4	6	1	+		7	51	71	6	+		4	28	34	2			2	3	2				219
84/ 80	2	6	9	4	1	+	11	72	107	44	10	+	5	35	46	16	1		+	4	3	+	+		378
79/ 75	1	7	13	8	7	2	14	78	128	87	63	16	9	41	45	24	12	1	1	4	4	1	+	+	566
74/ 70	2	6	12	11	12	14	13	67	131	89	107	79	13	44	46	20	21	11	2	4	3	2	+	+	707
69/ 65	2	6	10	10	14	30	12	69	108	90	109	137	13	40	35	20	20	18	2	4	2	1	1	1	751
64/ 60	1	5	10	8	13	20	9	66	107	71	94	124	11	37	41	17	20	17	2	4	2	1	+	1	681
59/ 55	1	5	8	6	10	17	8	60	98	62	66	99	11	38	36	22	19	22	2	5	4	1	1	1	600
54/ 50	+	5	7	5	9	10	6	52	105	56	63	64	6	38	38	14	19	20	2	8	6	2	1	1	535
49/ 45	+	3	9	5	7	7	3	52	102	49	49	57	5	37	48	21	20	23	1	6	6	2	2	2	512
44/ 40		1	8	4	4	5	2	38	107	60	48	47	1	25	61	26	23	23		4	12	5	3	3	510
39/ 35		1	7	6	6	9	+	20	111	85	78	64	+	10	73	52	37	34	+	3	13	8	7	5	627
34/ 30		1	6	5	10	17		9	99	103	116	125	+	8	56	57	54	52	+	1	11	8	5	7	747
29/ 25		+	3	7	10	14		5	57	82	104	83		4	36	44	52	32		1	8	8	5	4	557
24/ 20		1	4	4	8	7		3	46	57	82	50		3	30	36	35	15		1	6	8	9	2	405
19/ 15		1	3	4	4	4		4	33	50	56	25		2	23	31	23	4		+	5	6	4	+	281
14/ 10		1	2	3	4	3		3	27	35	44	11		2	20	22	18	2		+	8	5	3	+	211
09/ 05		+	3	1	4	1	+	4	27	22	35	1		2	17	15	9			+	6	3	2		152
04/ 00			2	2	3	1		1	16	23	22	+		2	16	9	4			+	2	2	1		104
-01/-05			1	1	2	+		2	12	12	12	+	+	2	8	2	2				2	1	+		59
-06/-10			1	1	+			1	8	3	3			1	3	2	+				+	+			23
-11/-15			+	+				1	1	3				1	1	+									8
-16/-20				+					+	1															1
TOTAL	9	54	124	93	126	159	90	701	1524	1091	1159	983	87	429	726	453	388	273	15	52	104	63	42	25	8767

In Tables A and C, occurrences are for the average year (10-year total divided by 10). Values are rounded to the nearest whole number, but not adjusted to make their sums exactly equal to column or row totals. "+" indicates more than 0 but less than 0.5.

C OCCURRENCES OF PRECIPITATION AMOUNTS:

INTENSITIES	FREQUENCY OF OCCURRENCE FOR EACH HOUR OF THE DAY — A.M. HOUR ENDING AT												P.M. HOUR ENDING AT												NO. OF DAYS WITH
	1	2	3	4	5	6	7	8	9	10	11	NOON	1	2	3	4	5	6	7	8	9	10	11	MID.	
TRACE	27	28	30	32	34	34	36	34	35	33	32	32	34	34	30	31	30	28	28	27	28	28	28	29	69
.01 IN	8	7	9	8	8	8	8	7	6	6	7	6	6	5	5	6	6	6	7	6	8	5	8	6	12
.02 TO .09 IN	9	10	11	11	11	12	10	12	11	12	11	10	9	9	11	9	9	9	9	11	9	9	8	9	36
.10 TO .24 IN	4	4	2	3	3	2	3	2	3	2	2	2	1	2	1	2	2	2	3	2	2	3	2	3	20
.25 TO .49 IN	1	1	1	1	1	+	+	1	1	1	1	1	+	+	+	1	1	1	1	1	+	1	+	1	18
.50 TO .99 IN	+	1	1		+	+		+		+	+	+	+	+	+	+	+	1	+	+	+	+	1	+	12
1.00 TO 1.99 IN	+		+	+						+						+	+	+	+		+	+		+	5
2.00 IN AND OVER																									1
TOTAL	49	50	54	54	56	57	57	56	55	55	53	50	50	50	48	49	48	46	47	47	47	46	47	49	173

D PERCENTAGE FREQUENCIES OF CEILING–VISIBILITY:

VISIBILITY (MILES)	CEILING (FEET) 0	100-200	300-400	500-900	1000-1900	2000-2900	3000-4900	5000-9500	OVER 9500	TOT
0 TO 1/8	.2	.1	+	+	+	+		+	+	.4
3/16 TO 3/8	.1	.2	+	+	+	+	+		+	.4
1/2 TO 3/4	+	.3	.2	.2	.1	+	+	+	.1	.8
1 TO 2 1/2		.4	.9	1.2	.6	.1	.1	.1	.2	3.7
3 TO 6		+	.5	2.1	1.5	.6	.6	.7	2.4	8.4
7 TO 15		+	.1	1.2	4.3	3.7	5.0	7.4	64.6	86.3
20 TO 30										
35 OR MORE										
TOTAL	.4	1.0	1.8	4.6	6.5	4.5	5.7	8.2	67.3	100

B PERCENTAGE FREQUENCIES OF WIND DIRECTION AND SPEED:

DIRECTION	HOURLY OBSERVATIONS OF WIND SPEED (IN MILES PER HOUR) 1-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	47 & OVER	TOTAL	AV. SPEED
N	.1	.8	2.1	2.4	.9	.2	+	+		6.5	13.3
NNE	.1	.7	1.6	1.8	.5	.1	+			4.9	12.7
NE	.2	.9	1.7	1.2	.2	+				4.2	11.0
ENE	.1	.9	1.5	.8	.1	+				3.5	10.2
E	.1	1.0	1.7	.8	.1	+				3.9	10.2
ESE	.1	1.3	2.6	1.2	.2	+	+			5.4	10.4
SE	.2	1.7	3.8	1.9	.3	+				7.8	10.5
SSE	.1	1.5	3.5	2.2	.4	.1	+			7.8	11.1
S	.1	1.7	4.4	3.0	.6	.1	+			9.9	11.5
SSW	.1	.9	2.7	2.5	.7	.1	+	+		7.1	12.8
SW	.1	1.0	2.1	1.5	.5	.1	+	+		5.4	12.1
WSW	.1	.9	1.7	1.2	.4	.1	+	+		4.4	11.9
W	.1	1.2	1.8	1.1	.3	.1	+	+		4.7	11.5
WNW	.1	1.1	2.1	2.1	1.0	.6	.2	+	+	7.2	14.4
NW	.1	1.1	2.4	2.9	1.7	.7	.1	+	+	9.1	15.2
NNW	.1	.7	1.8	2.3	1.3	.4	.1	+		6.7	14.9
CALM	1.4									1.4	
TOTAL	3.3	17.3	37.5	29.0	9.5	2.7	.6	.1	+	100	12.1

E PERCENTAGE FREQUENCIES OF SKY COVER, WIND, AND RELATIVE HUMIDITY:

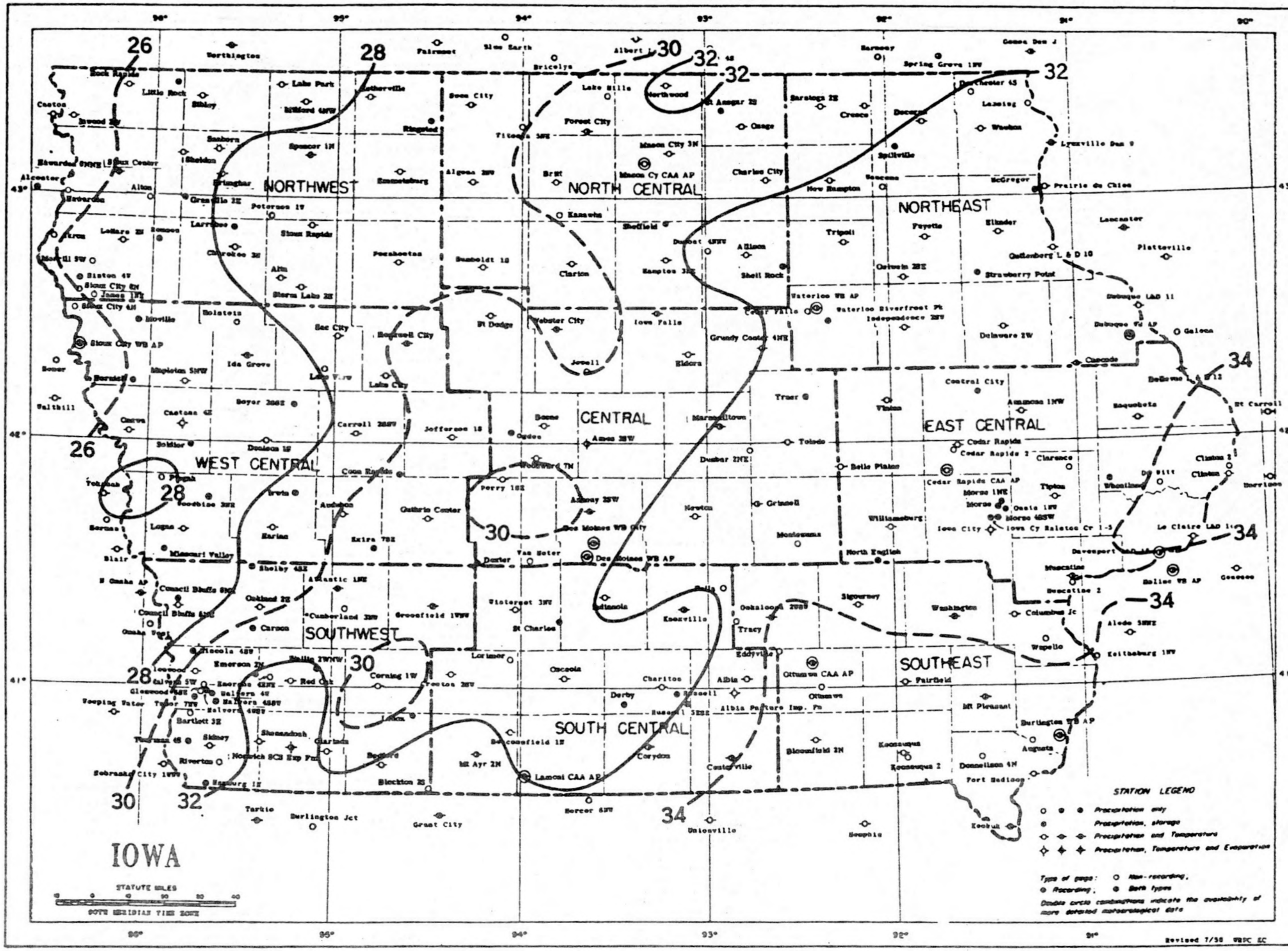
HOUR OF DAY	CLOUDS SCALE 0-10: 0-3	4-7	8-10	WIND SPEED (M.P.H.): 0-3	4-12	13-24	25 & OVER	RELATIVE HUMIDITY (%): 0-29	30-49	50-69	70-79	80-89	90-100
00	50	10	40	4	64	30	2	+	5	24	25	26	20
01	49	10	41	4	64	30	2	+	3	22	24	28	23
02	49	10	41	4	65	30	2	+	3	20	23	29	26
03	48	10	42	4	64	30	2	+	2	18	23	29	28
04	46	10	44	5	63	31	2	+	2	16	21	31	30
05	43	11	46	4	63	31	2		2	15	21	31	32
06	39	11	50	5	61	32	2	+	2	14	21	33	31
07	37	11	52	5	57	36	2		2	18	24	31	25
08	34	12	54	4	52	41	3	+	5	26	25	25	19
09	33	12	54	4	47	45	4	+	9	34	23	19	14
10	34	13	53	3	44	48	5	1	16	38	19	14	11
11	33	14	53	3	41	50	6	2	23	38	16	11	10
12	32	15	53	2	40	51	6	4	28	36	14	9	9
13	32	15	53	2	39	52	7	6	31	34	13	9	7
14	31	17	52	2	38	53	7	8	32	33	12	8	7
15	31	18	52	2	40	52	6	9	33	32	12	8	7
16	32	16	52	2	43	50	5	9	32	32	12	8	7
17	35	15	50	2	51	43	4	6	29	33	14	9	8
18	39	14	48	3	59	35	3	4	26	35	15	11	9
19	42	13	45	3	63	32	2	2	19	35	20	14	11
20	45	13	43	3	65	30	2	1	13	34	21	17	13
21	47	12	41	3	64	30	2	1	10	32	23	20	14
22	50	11	39	3	64	30	2	+	7	30	24	22	16
23	50	11	39	3	64	31	2	+	5	27	24	26	16
AVG	40	13	47	3	55	38	3	2	14	28	19	20	16

APPENDIX D

MEAN MINIMUM AND MAXIMUM TEMPERATURES (F)
FOR JANUARY AND JULY, AND
MEAN ANNUAL PRECIPITATION (INCHES) IN IOWA[a]

[a] U.S. Department of Commerce, Climates of the States - Iowa, 1967, p. 670-674.

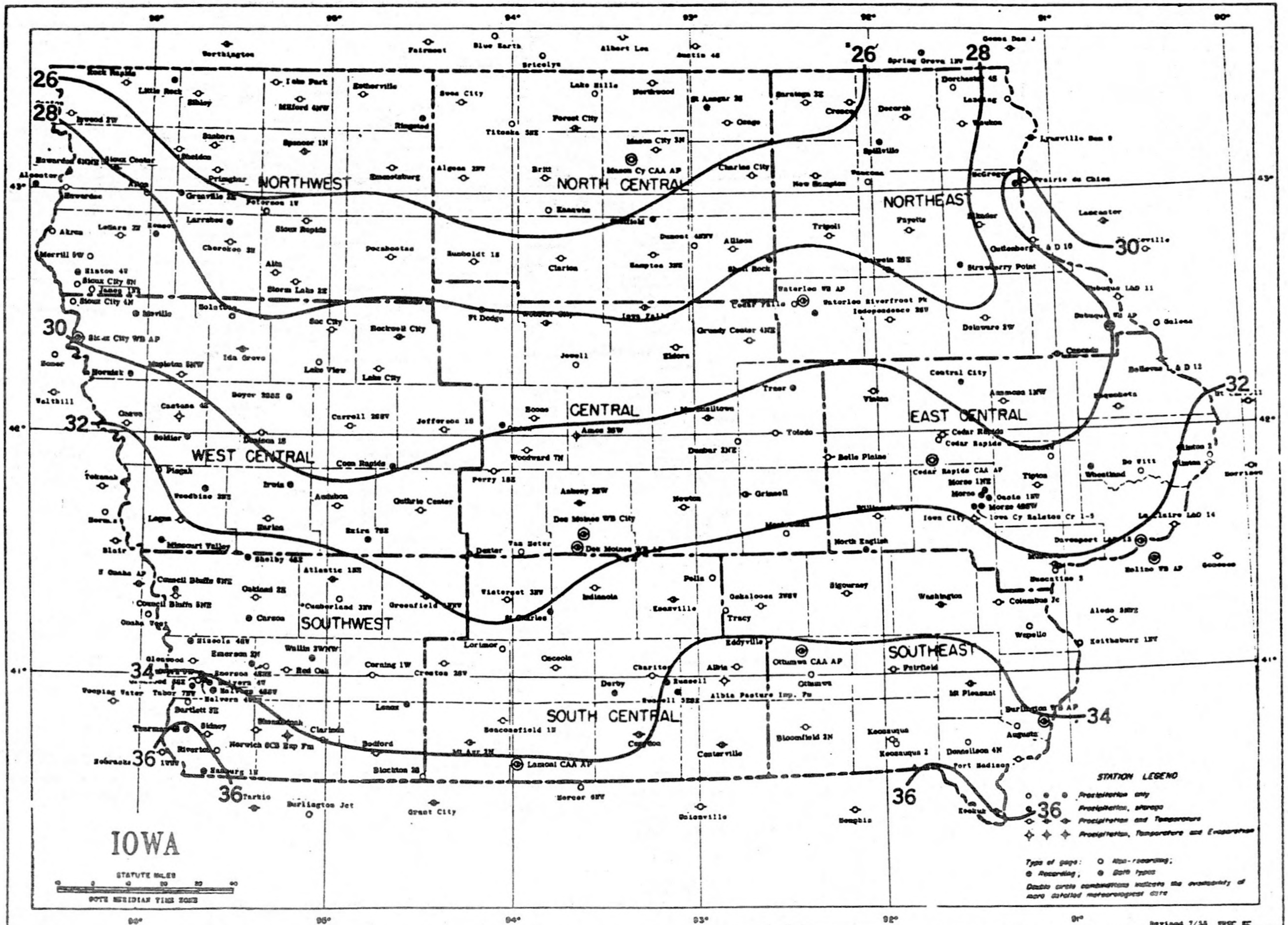
Mean Annual Precipitation, Inches



Based on period 1931-55

Isolines are drawn through points of approximately equal value. Caution should be used in interpolating on these maps.

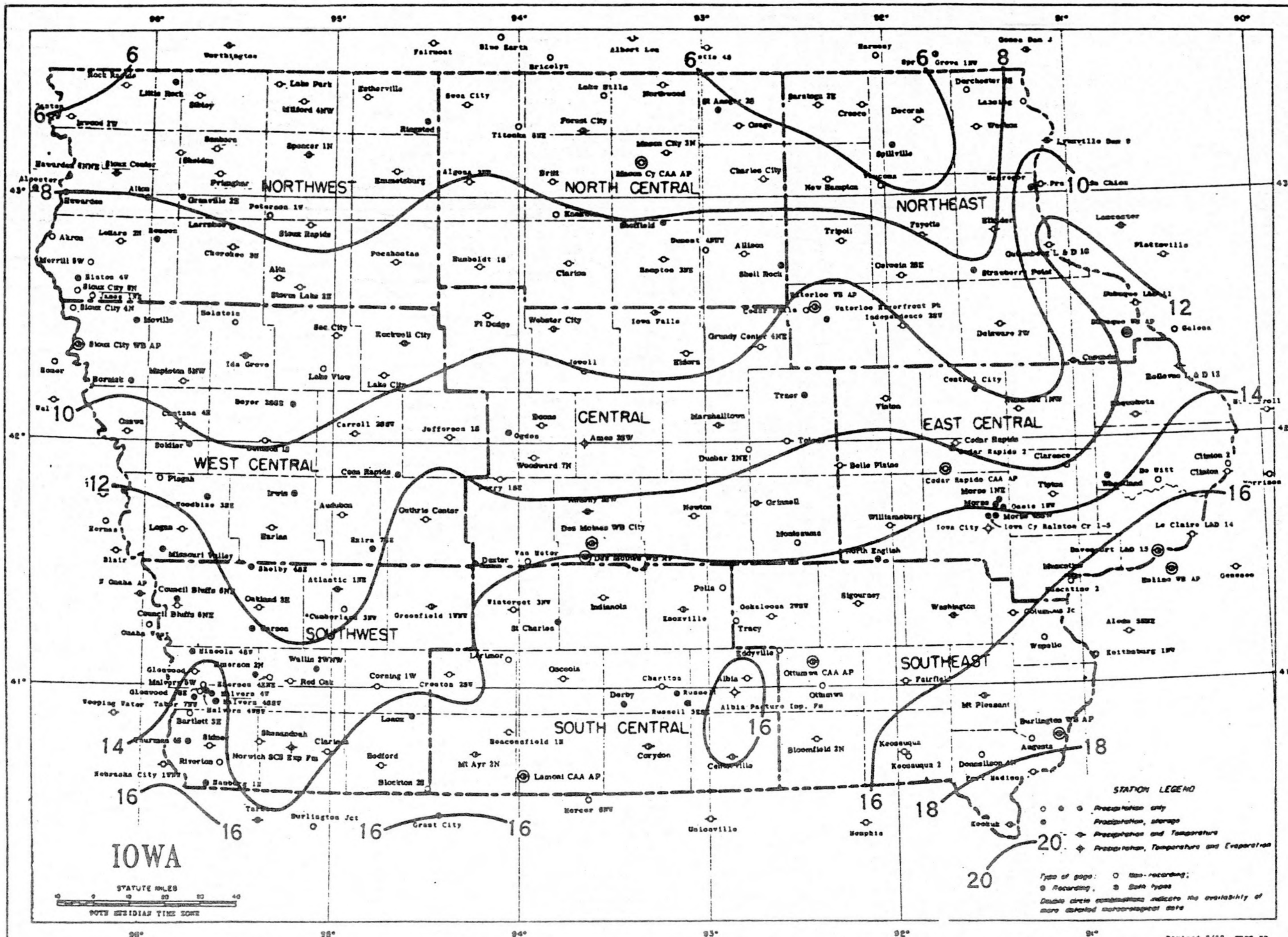
Mean Maximum Temperature (°F.), January



Based on period 1931-52

Isolines are drawn through points of approximately equal value. Caution should be used in interpolating on these maps .

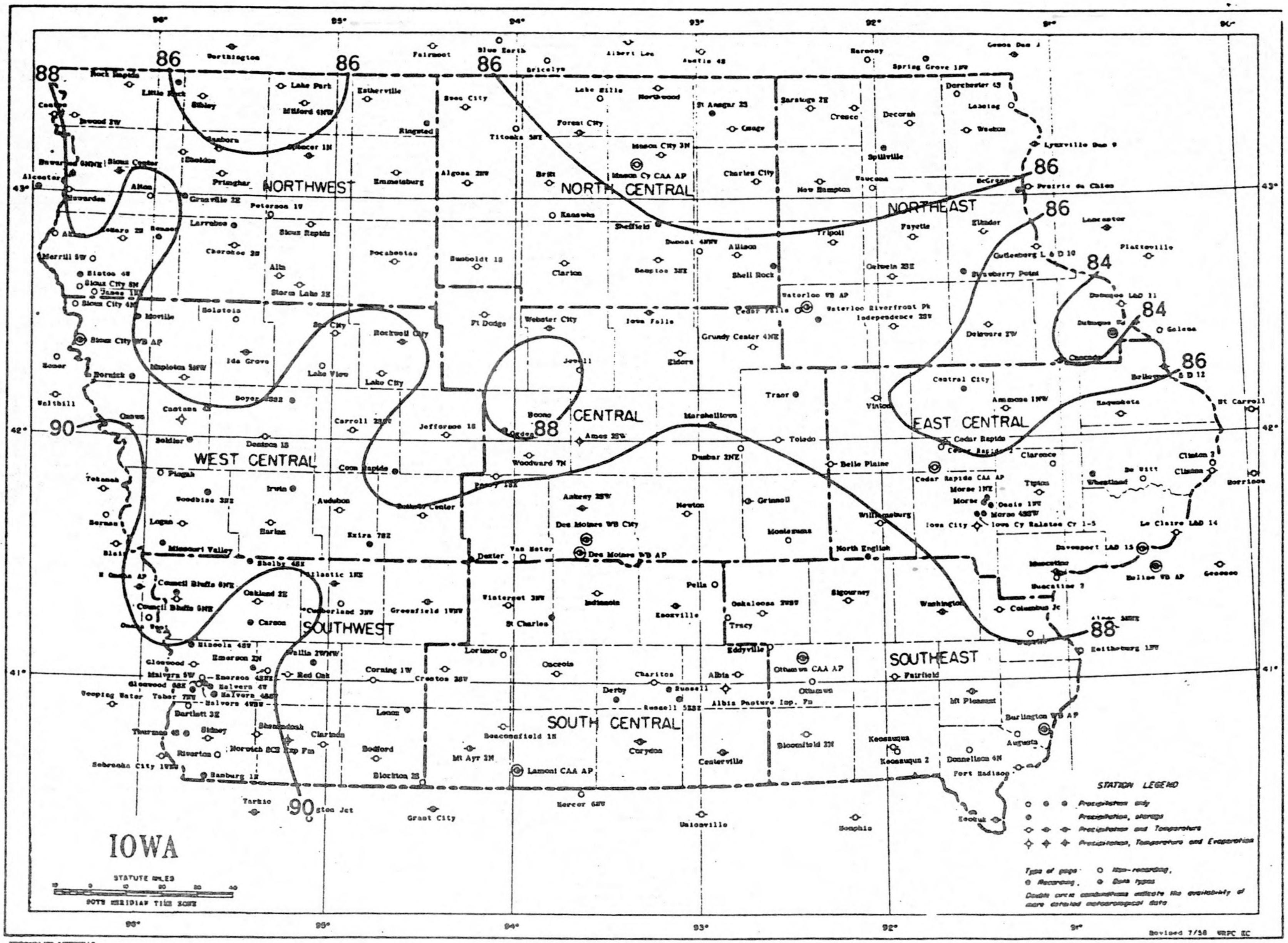
Mean Minimum Temperature (°F.), January



Based on period 1931-52

Isolines are drawn through points of approximately equal value. Caution should be used in interpolating on these maps.

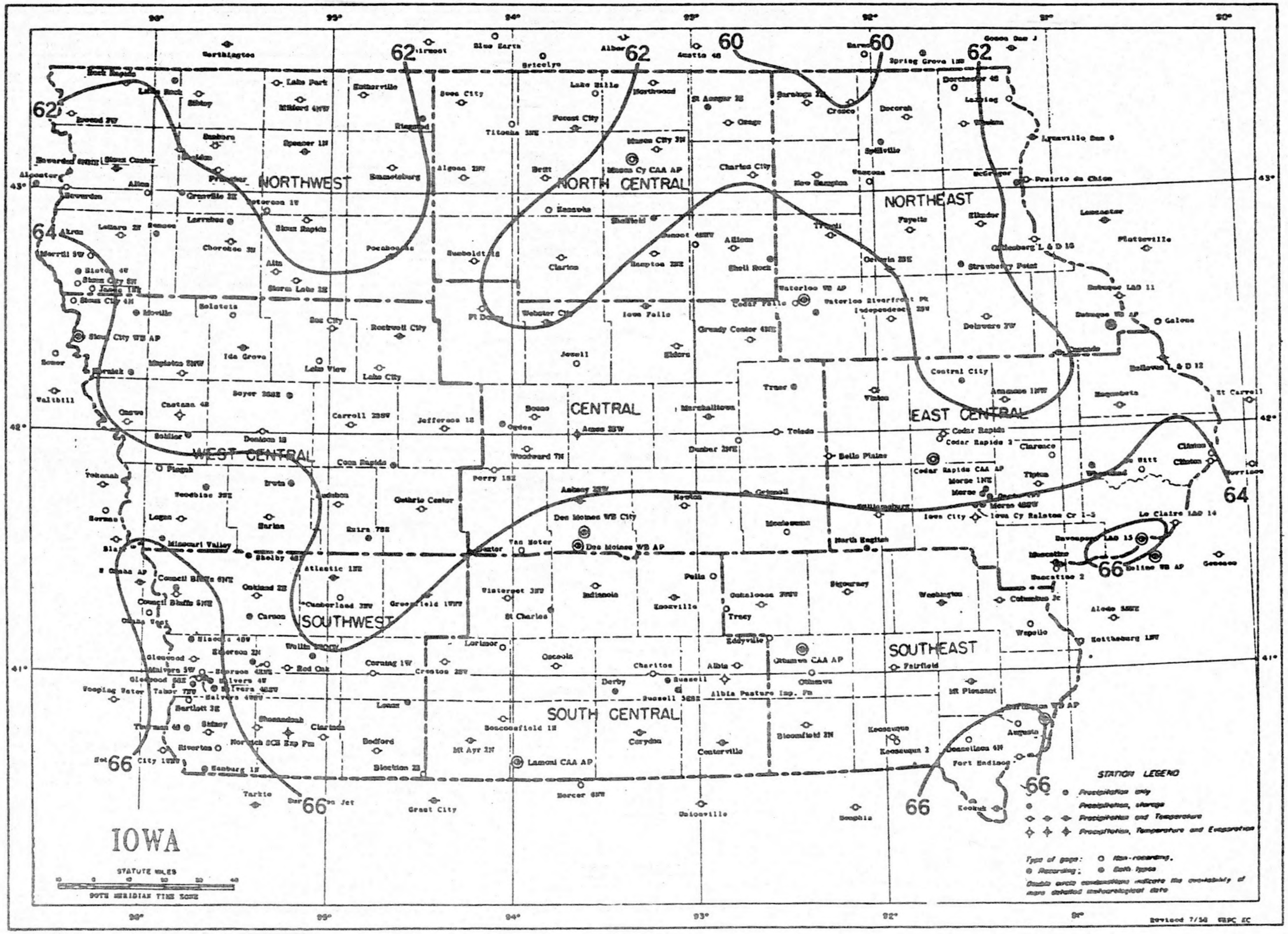
Mean Maximum Temperature (°F.), July



Based on period 1931-52.

Isolines are drawn through points of approximately equal value. Caution should be used in interpolating on these maps.

Mean Minimum Temperature (°F.), July



Based on period 1931-52

Isolines are drawn through points of approximately equal value. Caution should be used in interpolating on these maps.