Book 16
Climatic Data

Seafarer Site Survey
Upper Michigan Region

for
U.S. Navy
Naval Electronic Systems Command
Washington, D.C.

by
EDAW inc.
under contract to
GTE Sylvania
Communication Systems Division

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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20 ABSTRACT (Continue on reverse side if necessary and identify by block number) The Study Area has a temperate continental climate of the cool summer type. The hottest summer months are July and August with average approximate high and low temperatures of 75°F and 56.5°F, respectively. The coldest temperatures occur from December through March with mean high temperatures falling between 38.7°F and 22.5°F and lows between 20°F and 1.3°F. The winter climate in the study area is air mass controlled and hence is relatively unpredictable as to its severity from year to year.

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20. Precipitation in the area is in the 30-32 inch range and average annual snowfalls range from 60 inches in the south to 120 inches in the north.

BOOK 16

CLIMATIC DATA
of the
UPPER MICHIGAN REGION
PROJECT SEAFARER

for
U. S. Navy. Naval Electronic Systems Command

by
EDAW, Inc., 50 Green Street, San Francisco 94111

Under Contract to
GTE Sylvania, Communication Systems Division

April, 1976

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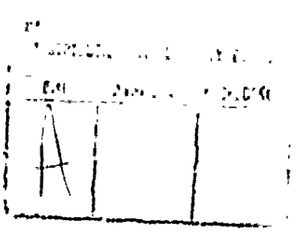


SUMMARY

The Study Area has a temperate continental climate of the cool summer type. Winter temperatures along the Lake Superior shore are from 6°F to 8°F warmer than the rest of the area, and in the summer 5°F to 6°F cooler. The hottest months of the summer are July and August with average high temperatures from 75.7° to 74.0° and low temperatures from 57.6°F to 57.5°F. The recorded high for the area is 102°F at Marquette, Michigan, in August 1947. The coldest temperatures occur in December, January, February, and March. During these months the mean high temperatures fall between 38.7°F and 22.5°F with the mean low temperatures ranging from 20°F to 1.3°F. The record low temperature of -46°F was recorded in February of 1951, at Kenton Weather Station in Houghton County.

The maximum depth of freezing in the Study Area averages 5' but is highly variable and can range from the surface only to 10' below the surface. Variation in the frost line is directly related to the amount of snow cover, therefore, the deeper the average snowfall the shallower the frost line. The variability in temperature and precipitation from year to year results in a corresponding variation in the depth of freezing from year to year.

Precipitation in the Study Area is from less than 30" to more than 32" and is evenly distributed throughout the year. Because of the even distribution of precipitation there is no definite wet or dry season. However, the summer rainfall is harder and of a shorter duration than other seasons, making the periods without rain longer and the summer seem dryer.

Snowfall occurs in the Study Area from September until May. The mean total snow depth at Marquette for each of these months is from 0" to 25" with the monthly maximum up to 52.6". Average annual snowfall for the site ranges from 120" in the northeastern part of the Study Area to 60" in the southern tip (see Climatic Data Map). In Marquette the greatest snowfall on record for any winter was 189.1" during the 1890-1891 season. Least snowfall for any season was 53.4" in 1940-1941.

In Marquette the average date of the first occurrence of freezing temperatures in autumn is October 20. The mean annual freeze-free period varies over the Study Area from more than 120 days along the Lake Superior shoreline to less than 60 days in the west central part.

In the Study Area, large annual temperature ranges are common due to extremely cold winters. These cold temperatures are caused by the southward advance of polar highs. These polar air masses are composed of extremely cold dry air which dominates the area until storms moving up from the south can displace them. The climate of the Study Area in the winter is an air mass controlled climate, and because of this is relatively unpredictable as to its severity from one year to the next.

EVOLUTION

The Upper Peninsula of Michigan has a temperate continental climate of the cool summer type. This is, especially in the summer, a land controlled climate which extends from 35° to about 50° latitude and east of the 100 meridian in the northern interior of the United States and southern Canada.

Large annual temperature ranges are common in this zone due to extremely cold winters. The severity of winters differs greatly from year to year because their temperatures are primarily air mass controlled and so fluctuate with the advance and retreat of polar highs.

There are three major factors which affect the winter climate of the Study Area: polar outbreak highs moving south out of Canada, deep cyclonic storms moving north out of Texas, and the relationship of the Study Area to the Great Lakes.

Polar outbreak highs are usually preceded by mild, warm fronts which bring rain or snow. After these fronts move through the area, winds shift from southwest to north and initiate a rapid drop in temperature as the polar high advances southward. This temperature drop is referred to as a cold wave and is typical of the winters of a continental climate. Cold waves end when deep cyclonic storms, originating in Texas, move northward bringing with them warmer temperatures, and rain or snow. The climate of this region is also modified somewhat by the Great Lakes. In the fall the lakes decrease the severity of the first cold winds from the north by warming them slightly. They also increase the moisture content of the north winds, thus increasing the snowfall in the area. This increased snowfall, however, is a localized effect and extends only about 20 miles inland.

The summer temperatures are less controlled by storms and exhibit a greater diurnal regularity. Two major elements control the summer weather: hot waves, and cold front thunderstorms. Hot waves are a response to long continued advection of tropical air masses by south winds. Eastward advancing cold front thunderstorms end the hot waves, shifting the winds from the south to the northwest and bringing cooler temperatures to the area.

DISTINCTIVE UNITS AND CHARACTERISTICS

Introduction

One climate type extends over the entire Study Area. However, there is some variation due to the localized effect of the Great Lakes.

Illustrations of Climatic Data

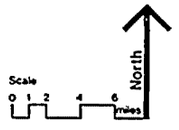
The climatic data are delineated in three forms. The average annual snowfall is displayed on the Climatic Data Map; temperature and precipitation data are shown on small schematic maps (Figures 1, 2, and 3); and climatic data for the City of Marquette is plotted in graph form (Figures 4-8). (See Appendix A for exact readings used in making the graphs and additional climatic data.)

Seafarer Site Survey
Upper Michigan Region

by
EDAW inc.
San Francisco, California

under contract to
GTE Sylvania
Communication Systems Division
Needham Heights, Massachusetts

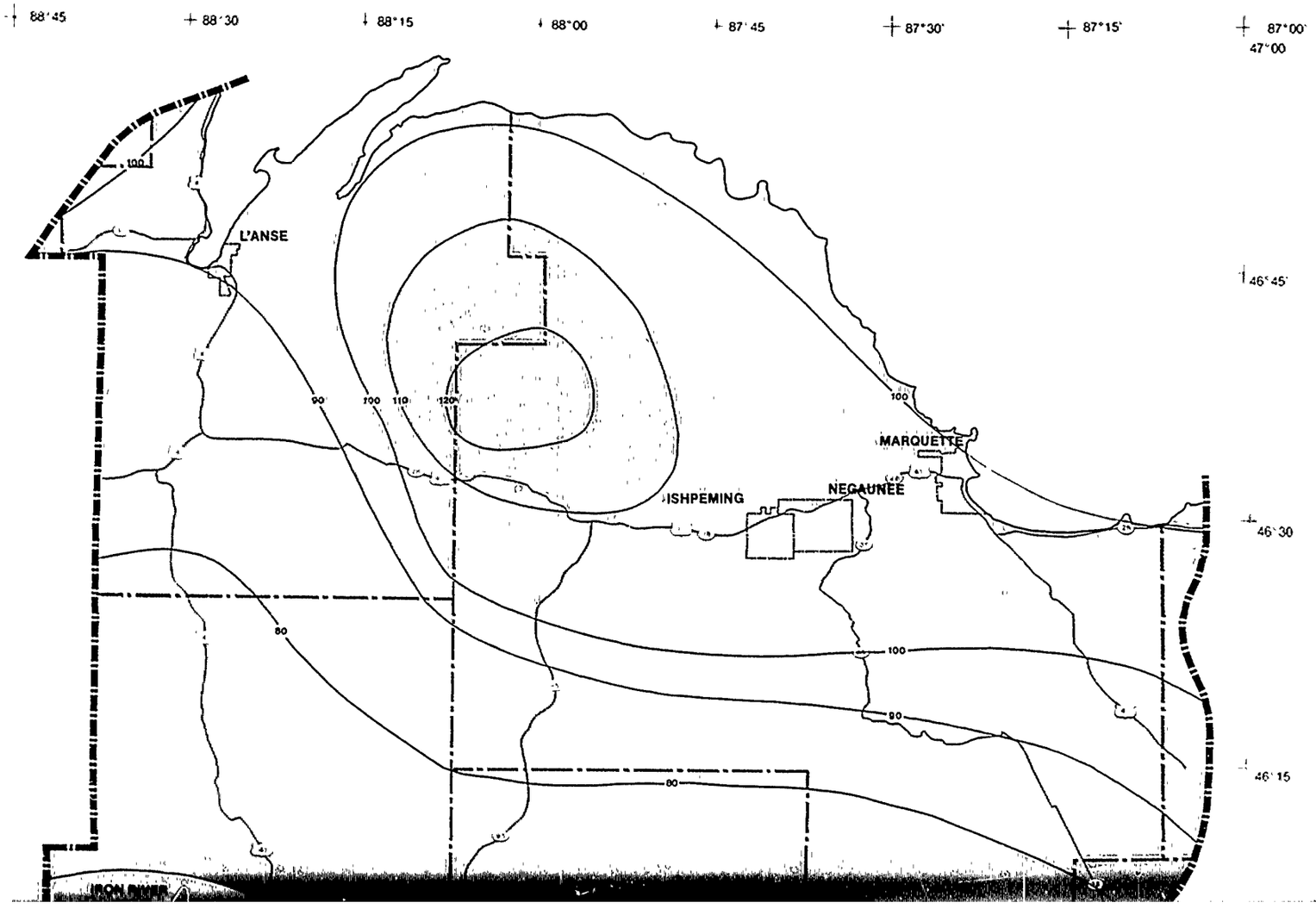
for
U.S. Navy
Naval Electronic Systems Command
Washington, D.C.

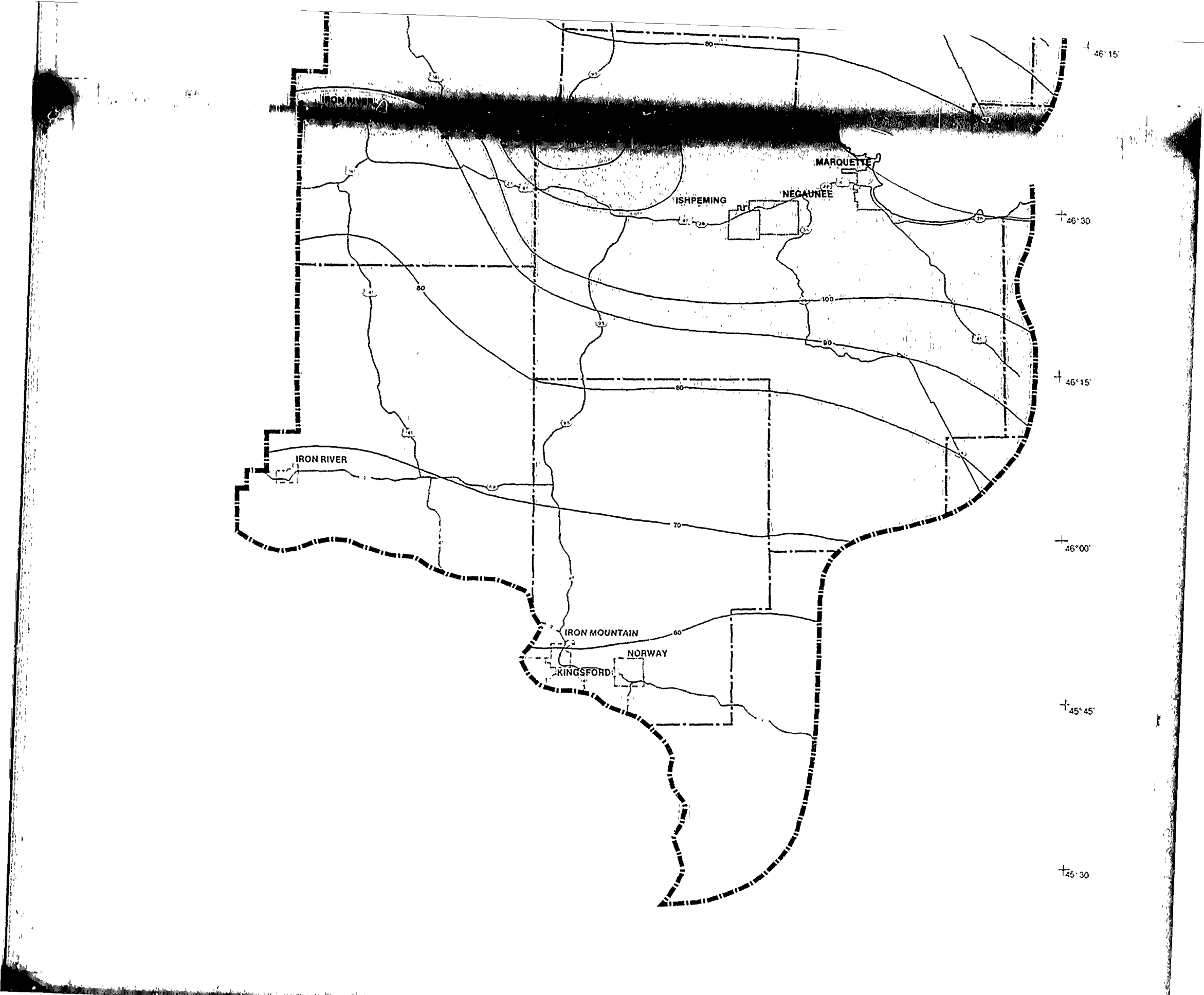


CLIMATE

GENERALIZED SNOWFALL ZONES
(Average Annual Snowfall in Inches)

- 110 - 130
- 90 - 110
- 70 90
- 50 70




IRON RIVER
MARQUETTE
ISHPEMING
NEGAUNEE
IRON RIVER
IRON MOUNTAIN
NORWAY
KINGSFORD
80
100
90
80
70
60
46°15'
46°30
46°15'
46°00'
45°45'
45°30

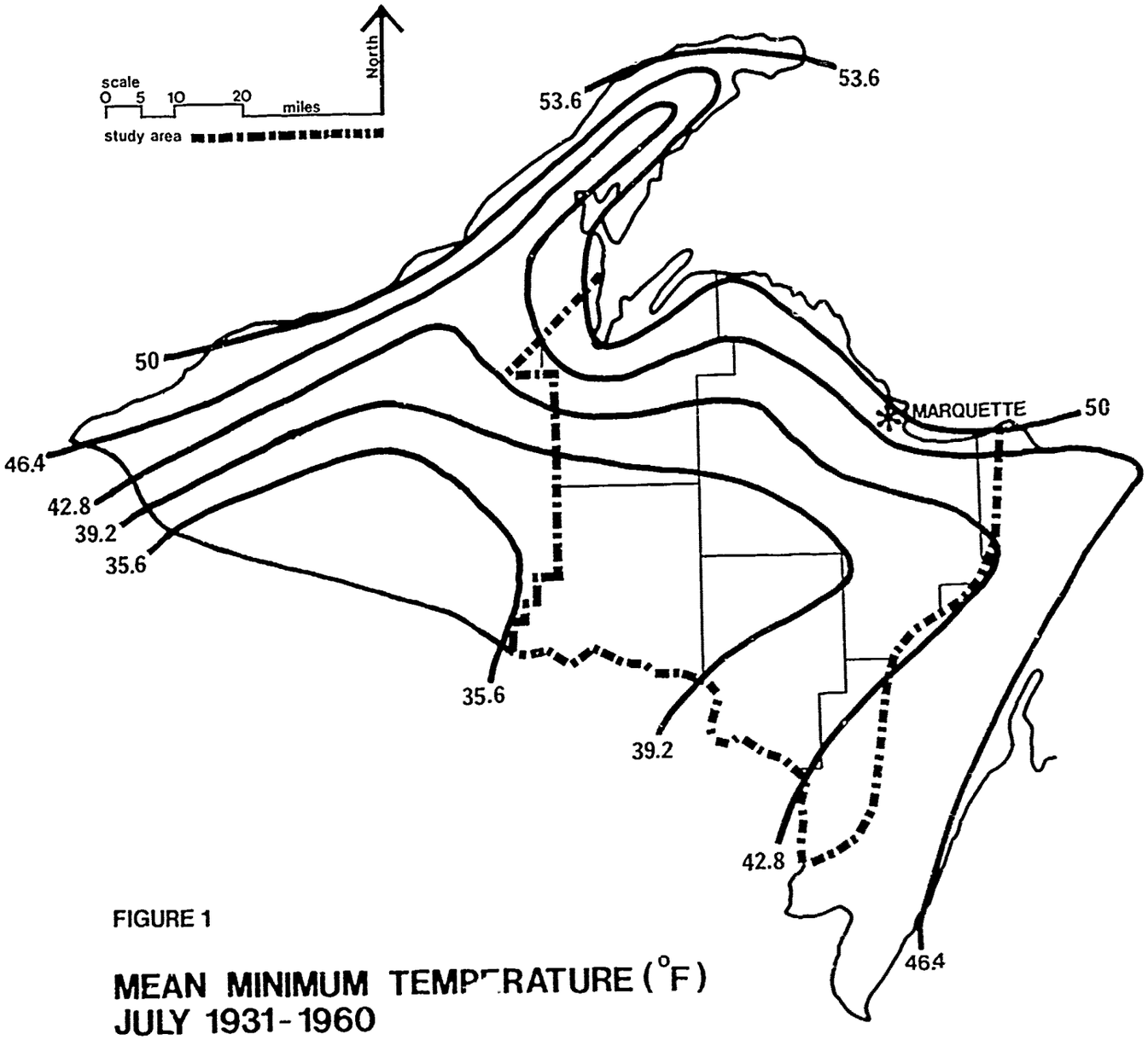


FIGURE 1

MEAN MINIMUM TEMPERATURE (°F)
JULY 1931-1960

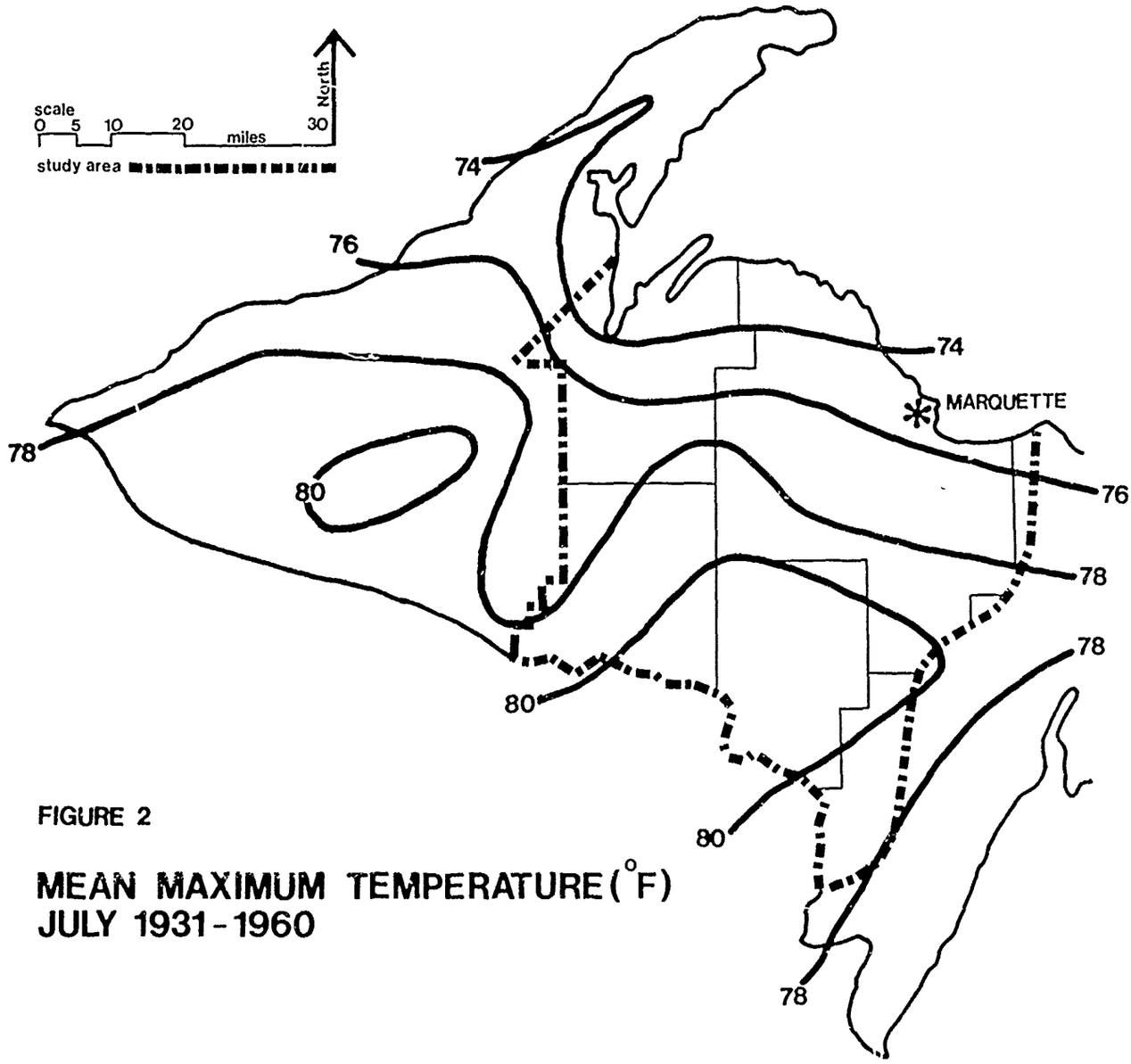


FIGURE 2

MEAN MAXIMUM TEMPERATURE (°F)
JULY 1931-1960

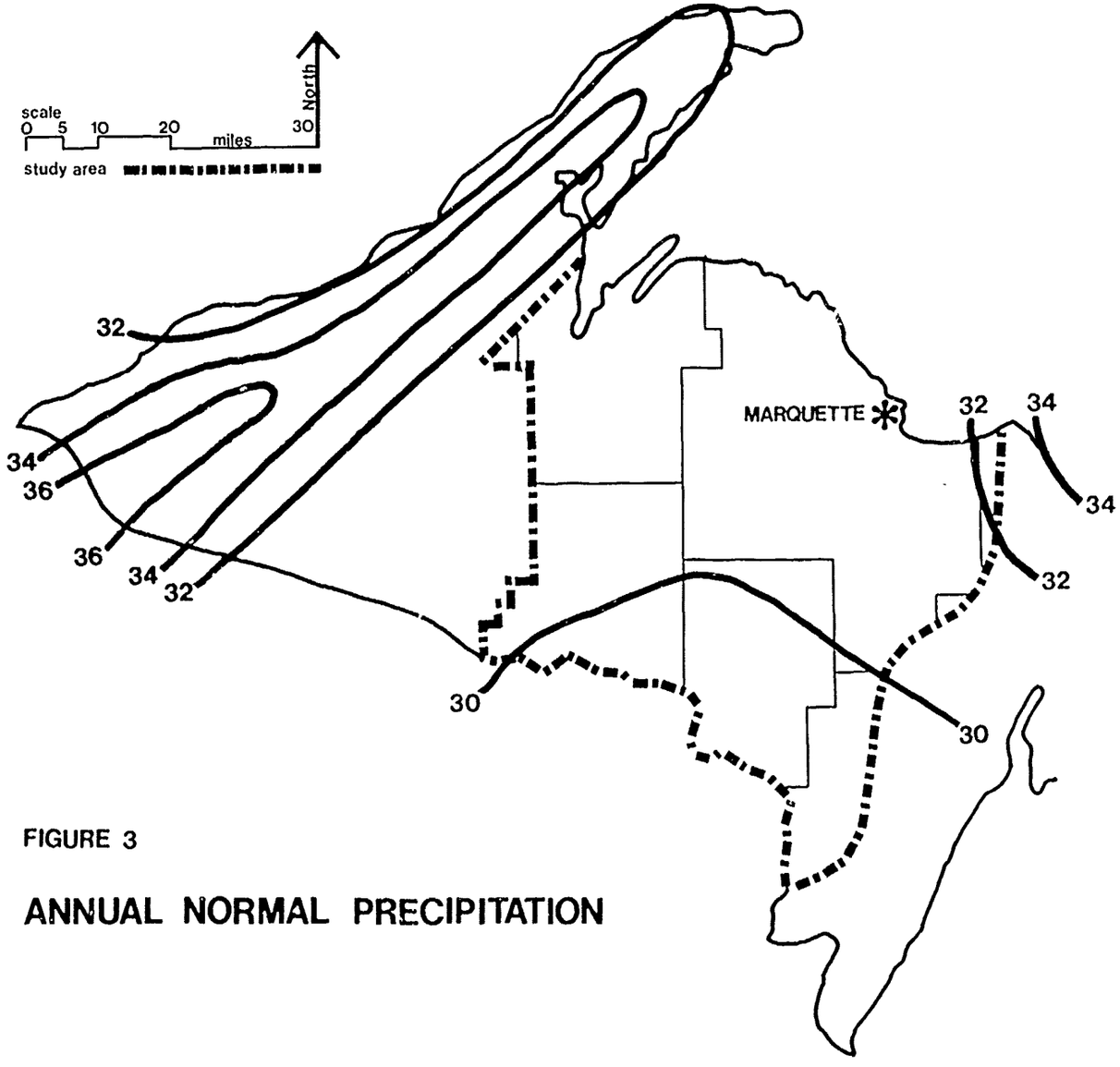


FIGURE 3

ANNUAL NORMAL PRECIPITATION

FIGURE 4

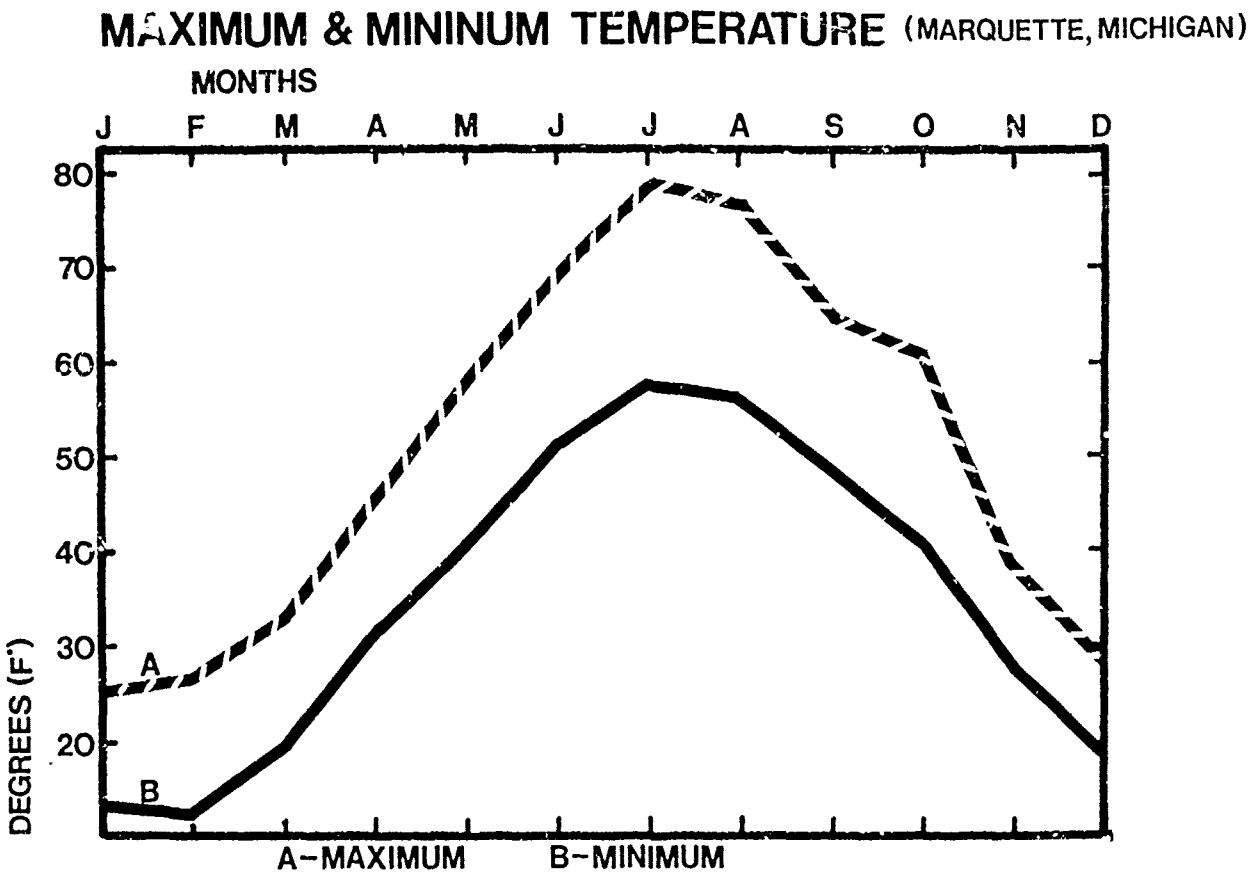
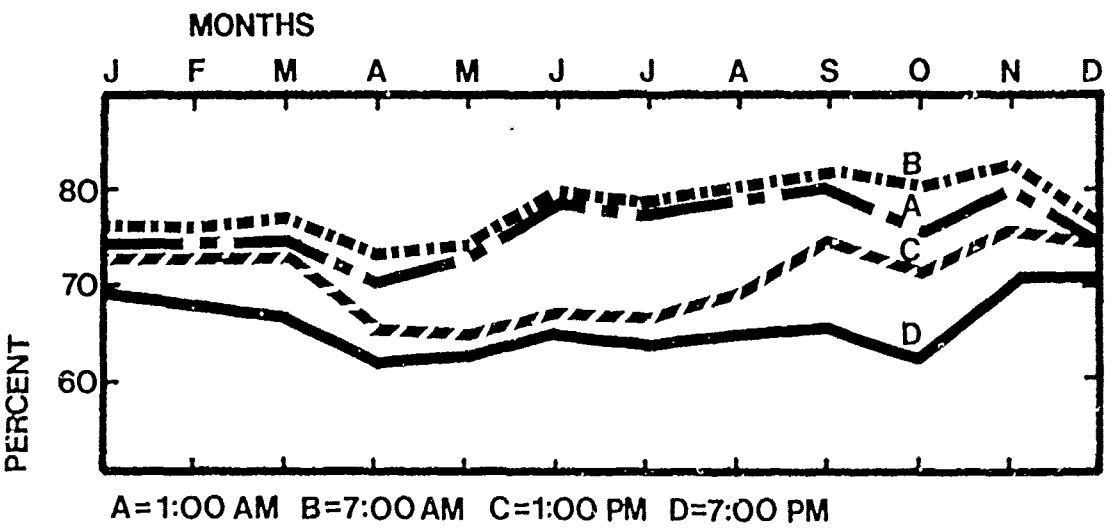


FIGURE 5



F GURE 6

MAXIMUM & MEAN PRECIPITATION (MARQUETTE, MICHIGAN)

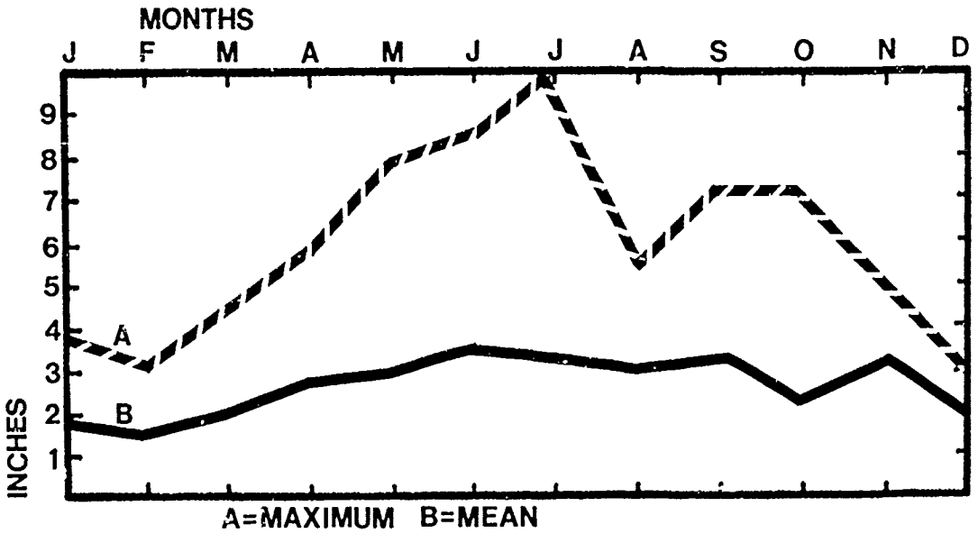


FIGURE 7

MAXIMUM & MEAN SNOW FALL (MARQUETTE, MICHIGAN)

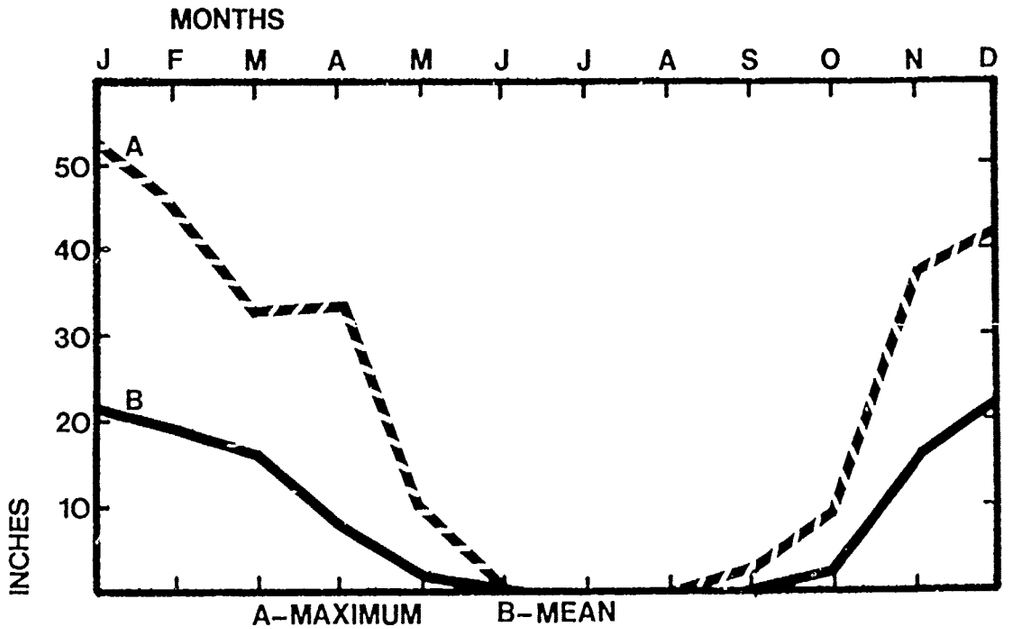
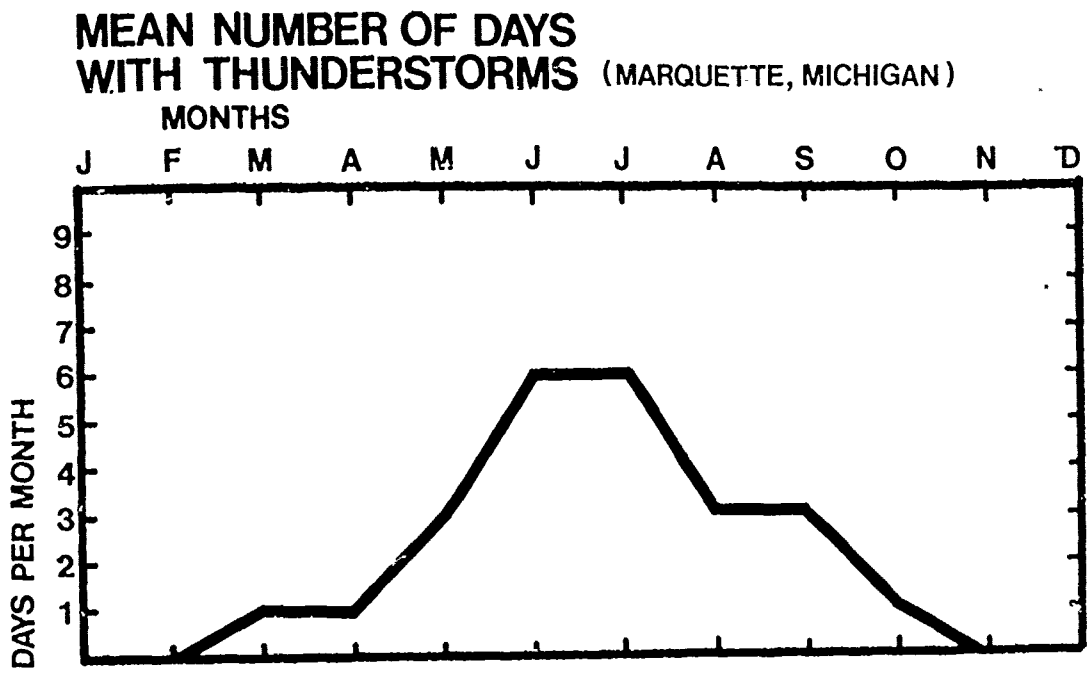


FIGURE 8


MEAN NUMBER OF DAYS
WITH THUNDERSTORMS (MARQUETTE, MICHIGAN)
MONTHS
J F M A M J J A S O N D
DAYS PER MONTH
1
2
3
4
5
6
7
8
9

RELATIONSHIP TO OTHER DATA

The climate has a strong relationship to all of the other natural and cultural processes. It controls the life cycles of animals and plants, and the agricultural practices of man. It affects the character of the stream flow and the amount of ground water available.

The temperature and humidity of a climate are directly related to the effectiveness of mechanical cooling systems. Extreme and rapid changes in weather affect the curing time of concrete, the productivity and safety of workers, and the transportation of goods. The depth of freezing has a strong effect on all forms of construction.

VALIDITY

Form of Data Presentation

Climatic data have been recorded in three forms: a large-scale mylar map (1" = 2 miles) reduced for this report; small-scale schematic maps (Figures 1-3), and graphs of data from a typical weather station in the Study Area (Figures 4-8).

Snow depth data were plotted at the large scale, 1" = 2 miles. This was done because these data are a primary guide to the depth of freezing in the area. Therefore, in order that it may be used in the analysis process it was plotted at the same scale as the other data groups.

Mean maximum and minimum temperature and normal annual precipitation data are plotted on small scale schematic maps. This type of plotting allows one to understand the variation in climate over the site and then when reading the graphs for the Marquette weather station (represented by * on the small maps), the relationship of that data to the rest of the Study Area can be more clearly understood. The other relevant climatic data were plotted in graph form to emphasize their seasonal fluctuation.

Selection of Data Collection Points

The weather station at Marquette was the only one within the Study Area that had reasonably complete data. These data were therefore selected as the source for figures 4-8.

Data Sources

The source for the data used in plotting all graphs was the U. S. Department of Commerce National Oceanic and Atmospheric Administration, Environmental Data Service, Local Climatological Data of Marquette Michigan. Temperature and precipitation data were recorded for a 29 year period ending in 1960; snowfall data were recorded for 34 years ending in 1971; and humidity and thunderstorm data were recorded for 27 years ending in 1971.

The small-scale temperature and precipitation maps and large-scale snowfall map were all plotted from data recorded from 1931 until 1960 by the Michigan Weather Service.

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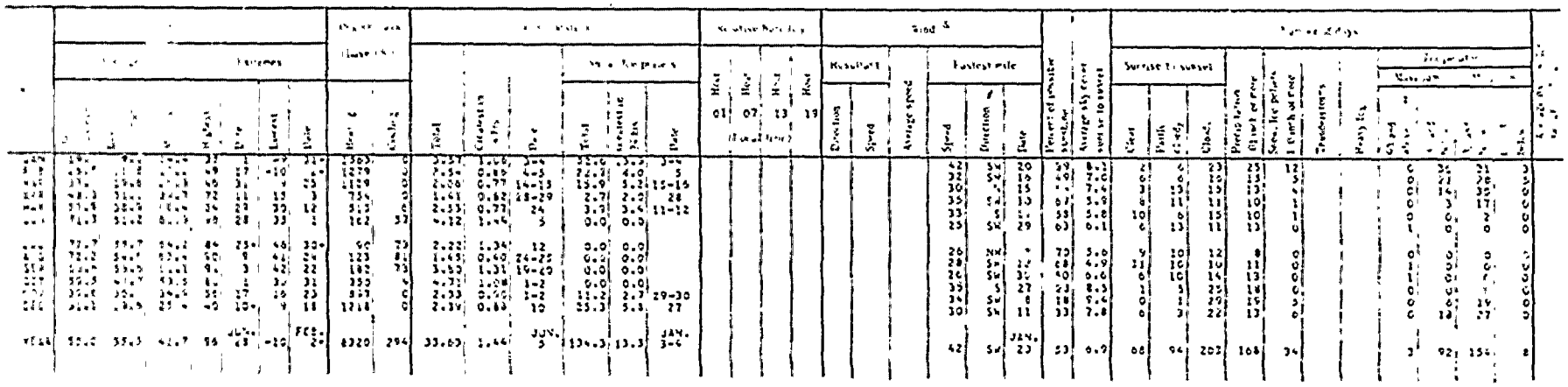
APPENDIX

CLIMATIC DATA

METEOROLOGICAL DATA FOR 1971

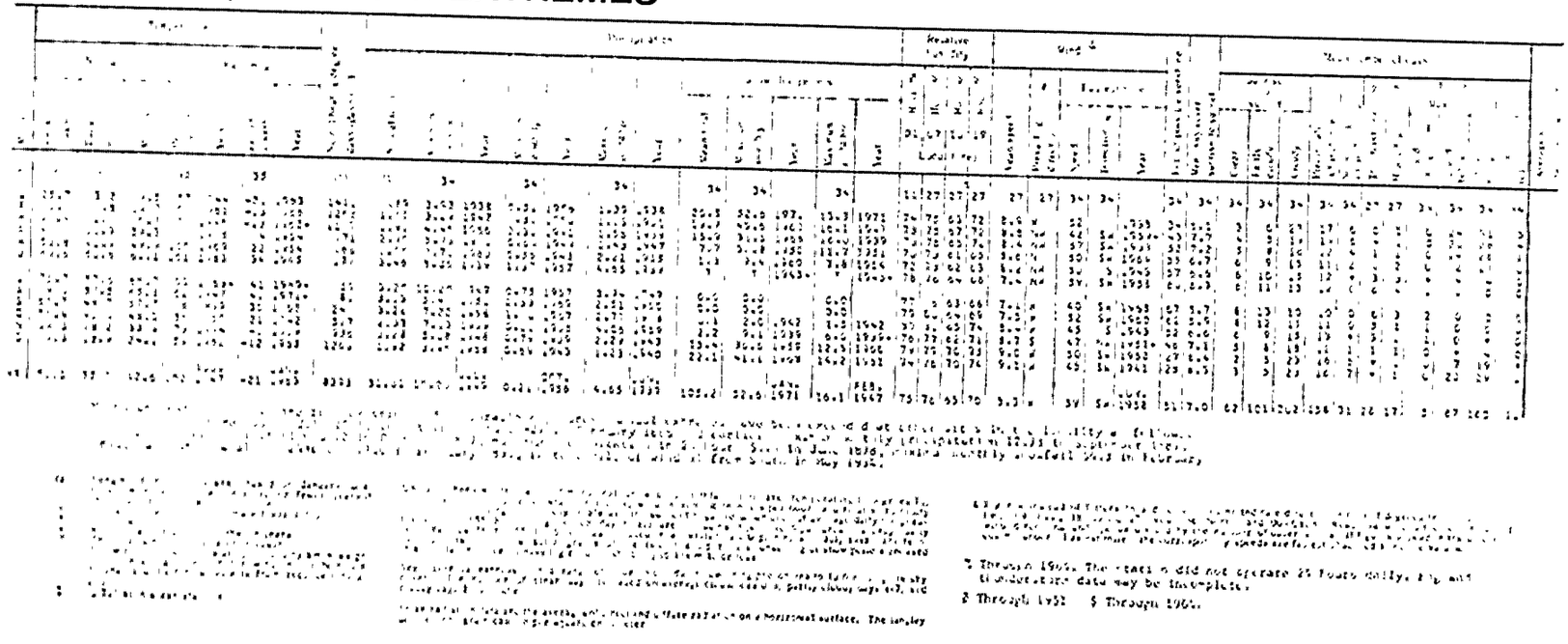


Source: U. S. Department of Commerce National Oceanic and Atmospheric Administration Environmental Data Service Publication. Local Climatological Data of Marquette, Michigan.

Dimensional Units:

Temperature - Degrees Fahrenheit
Precipitation - Inches
Snowfall - Inches
Wind- Miles per Hour

NORMALS, MEANS & EXTREMES



Source: U. S. Department of Commerce National Oceanic and Atmospheric Administration Environmental Data Service Publication. Local Climatological Data of Marquette, Michigan.

Dimensional Units:

Temperature - Degrees Fahrenheit
Precipitation - Inches
Snowfall - Inches
Wind - Miles per Hour

PRECIPITATION (inches)

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
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SNOWFALL (inches)

Season	July	Aug	Sept	Oct.	Nov.	Dec	Jan	Feb	Mar.	Apr.	May	June	Total
1932-33	0.0	0.0	0.0	2.1	5.3	10.6	15.5	35.3	18.6	12.3	0.0	0.0	99.9
1933-34	0.0	0.0	0.0	6.4	25.0	20.2	27.4	11.0	20.6	21.4	0.0	0.0	132.0
1934-35	0.0	0.0	0.0	1.0	12.1	24.0	26.3	6.5	7.4	7.3	0.0	0.0	83.0
1935-36	0.0	0.0	1.0	6.9	26.3	28.8	28.1	24.0	33.8	3.8	0.0	0.0	152.7
1936-37	0.0	0.0	0.0	1.5	25.2	5.3	23.9	26.7	4.7	13.9	T	0.0	101.2
1937-38	0.0	0.0	0.0	4.5	16.0	27.0	40.5	12.2	7.9	3.6	T	T	111.7
1938-39	0.0	0.0	0.0	6.0	21.4	19.7	14.6	25.5	29.0	4.7	0.0	0.0	120.9
1939-40	0.0	0.0	0.0	9.1	8.2	13.7	25.5	16.9	8.8	19.2	2.4	0.0	103.8
1940-41	0.0	0.0	0.0	T	10.4	13.0	12.5	11.1	3.0	1.3	0.0	0.0	51.4
1941-42	0.0	0.0	0.0	0.1	12.3	7.6	5.3	8.1	17.3	6.2	T	0.0	56.9
1942-43	0.0	0.0	2.6	3.0	15.4	30.6	16.5	9.0	29.3	12.2	T	0.0	125.4
1943-44	0.0	0.0	0.0	3.0	11.7	6.9	8.3	16.1	23.6	7.7	3.4	0.0	80.9
1944-45	0.0	0.0	0.0	0.0	11.8	24.4	15.2	21.0	4.0	9.0	T	T	85.4
1945-46	0.0	0.0	T	0.6	14.2	21.7	17.6	12.6	2.8	2.9	T	0.0	72.3
1946-47	0.0	0.0	0.0	T	9.1	21.6	33.6	19.1	8.7	12.2	2.9	0.0	107.3
1947-48	0.0	0.0	0.6	0.0	7.7	17.9	21.4	10.6	9.4	5.3	T	0.0	73.1
1948-49	0.0	0.0	0.0	0.1	17.0	6.1	20.8	24.8	5.7	1.4	T	0.0	75.9
1949-50	0.0	0.0	0.0	4.6	35.2	20.0	43.7	22.0	21.3	32.8	2.2	0.0	182.0
1950-51	0.0	0.0	T	T	23.8	18.2	19.1	28.1	14.1	23.5	T	0.0	127.8
1951-52	0.0	0.0	T	6.8	16.3	13.9	25.1	15.6	11.6	7.7	T	0.0	91.0
1952-53	0.0	0.0	0.0	5.1	6.1	25.3	17.6	28.4	14.0	22.2	T	0.0	119.8
1953-54	0.0	0.0	0.0	T	8.7	23.3	19.4	7.4	21.3	0.9	6.7	0.0	89.6
1954-55	0.0	0.0	0.0	3.0	4.0	4.4	18.1	12.2	37.0	T	T	0.0	79.5
1955-56	0.0	0.0	0.0	2.0	18.0	20.4	9.2	6.2	16.0	8.4	T	0.0	87.3
1956-57	0.0	0.0	0.1	T	31.0	22.6	33.4	12.2	3.3	17.8	0.2	0.0	104.7
1957-58	0.0	0.0	T	7.4	24.2	28.2	27.2	33.8	12.4	4.5	T	0.0	121.4
1958-59	0.0	0.0	0.4	0.5	11.8	29.8	14.3	14.1	29.6	3.3	T	0.0	104.0
1959-60	0.0	0.0	0.0	3.0	36.5	17.3	29.1	41.6	30.9	14.2	9.4	0.0	181.1
1960-61	0.0	0.0	0.0	3.5	20.4	21.5	18.6	20.7	24.8	5.4	1.7	0.0	116.6
1961-62	0.0	0.0	T	T	8.2	23.3	26.1	25.9	22.0	2.0	1.3	0.0	116.8
1962-63	0.0	0.0	0.3	4.2	4.5	23.2	16.3	12.2	15.0	0.7	0.7	0.0	77.1
1963-64	0.0	0.0	0.0	T	2.4	27.8	11.6	21.7	26.2	3.6	0.0	0.0	91.3
1964-65	0.0	0.0	0.0	1.7	14.9	27.9	17.0	20.1	22.4	2.9	T	0.0	106.9
1965-66	0.0	0.0	T	0.3	12.6	7.6	23.4	13.0	31.2	12.4	0.3	0.0	98.1
1966-67	0.0	0.0	0.0	1.1	24.0	32.4	27.8	23.5	10.4	2.4	[illegible]	0.0	132.3
1967-68	0.0	0.0	0.0	1.4	17.4	6.2	21.6	44.4	4.1	5.5	T	0.0	94.5
1968-69	0.0	0.0	0.0	2.0	15.0	41.1	29.1	12.2	17.7	1.0	0.1	0.0	119.2
1969-70	0.0	0.0	0.0	4.1	7.5	30.9	35.8	18.3	21.1	0.9	1.4	0.0	122.4
1970-71	0.0	0.0	T	0.1	11.0	26.9	52.6	22.7	15.9	2.7	3.9	0.0	135.5
1971-72	0.0	0.0	0.0	0.0	11.2	23.3							

Source: U. S. Department of Commerce National Oceanic and Atmospheric Administration Environmental Data Service Publication. Local Climatological Data of Marquette, Michigan.

AVERAGE TEMPERATURE (°F)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
[illegible]													

TOTAL DEGREE DAYS

Season	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Total
1932-33	72	30	178	617	1023	1332	1272	1360	1250	814	447	22	8577
1933-34	26	65	142	637	1104	1466	1251	1313	1334	848	380	159	9033
1934-35	107	173	337	528	846	1339	1508	1213	1112	855	578	270	8849
1935-36	32	48	301	575	1019	1294	1512	1696	1140	928	459	259	9464
1936-37	68	101	210	687	1052	1200	1526	1238	1303	817	632	165	8731
1937-38	65	65	256	653	944	1383	1543	1188	990	766	461	263	8619
1938-39	68	42	215	660	918	1276	1554	1392	1294	950	631	178	8811
1939-40	32	42	283	640	869	1074	1472	1218	1310	824	639	242	8674
1940-41	93	109	201	313	674	1232	1308	1217	1214	592	32	204	8201
1941-42	42	105	195	542	851	1140	1372	1221	1229	825	476	224	7822
1942-43	49	71	319	527	937	1359	1551	1251	1340	843	449	215	8958
1943-44	22	65	335	320	987	1287	1170	1165	1274	849	387	187	8281
1944-45	69	72	244	521	814	1347	1303	1242	893	734	649	253	8377
1945-46	53	38	291	605	947	1359	1403	1340	845	695	523	221	8378
1946-47	37	137	201	440	909	1324	1356	1316	1168	922	650	298	8843
1947-48	104	33	270	296	1041	1302	1379	1303	1238	867	534	220	8648
1948-49	55	38	162	324	832	1260	1322	1224	1145	841	480	108	7926
1949-50	38	36	259	432	952	1268	1317	1271	1310	972	505	187	8808
1950-51	131	217	249	476	1036	1360	1455	1257	1213	783	383	259	8819
1951-52	69	136	329	597	1092	1369	1398	1199	1184	824	449	132	8387
1952-53	48	93	235	686	960	1336	1312	1214	1066	837	461	169	8057
1953-54	43	47	253	389	780	1150	1472	1004	1191	754	631	157	7889
1954-55	76	72	265	599	808	1213	1361	1248	1241	542	331	125	7914
1955-56	22	28	260	476	1026	1391	1300	1225	1272	852	540	159	8521
1956-57	101	64	358	363	920	1233	1607	1241	1182	697	482	188	8530
1957-58	62	84	235	516	933	1218	1292	1352	1070	672	501	253	8223
1958-59	91	95	106	477	843	1407	1617	1378	1164	787	326	143	8399
1959-60	43	37	206	670	1161	1091	1349	1253	1333	746	367	199	8615
1960-61	92	68	244	509	833	1368	1311	1119	1060	812	523	191	8342
1961-62	55	46	226	494	873	1313	1506	1409	1128	801	372	259	9334
1962-63	68	98	318	504	852	1339	1726	1467	1130	768	453	199	8928
1963-64	111	112	240	222	763	1422	1225	1193	1221	727	289	230	7685
1964-65	43	137	268	540	850	1359	1520	1370	1283	793	344	151	8696
1965-66	107	131	335	547	929	1133	1333	1223	1220	809	559	149	8479
1966-67	24	64	225	565	956	1262	1372	1446	1132	767	387	172	8901
1967-68	83	110	253	598	1010	1263	1454	1411	983	876	503	263	8533
1968-69	81	102	148	448	892	1262	1364	1242	1214	892	425	297	8240
1969-70	93	21	208	624	905	1215	1548	1323	1230	736	351	186	8558
1970-71	45	44	276	443	887	1257	1363	1279	1184	754	513	162	8364
1971-72	90	124	184	330	897	1218							

Source: U. S. Department of Commerce National Oceanic and Atmospheric Administration Environmental Data Service Publication. Local Climatological Data of Marquette, Michigan.